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AN 11-60AA-2

*HANDBOOK OF OVERHAUL
INSTRUCTIONS*

AUTOMATIC PILOT
TYPE C-1

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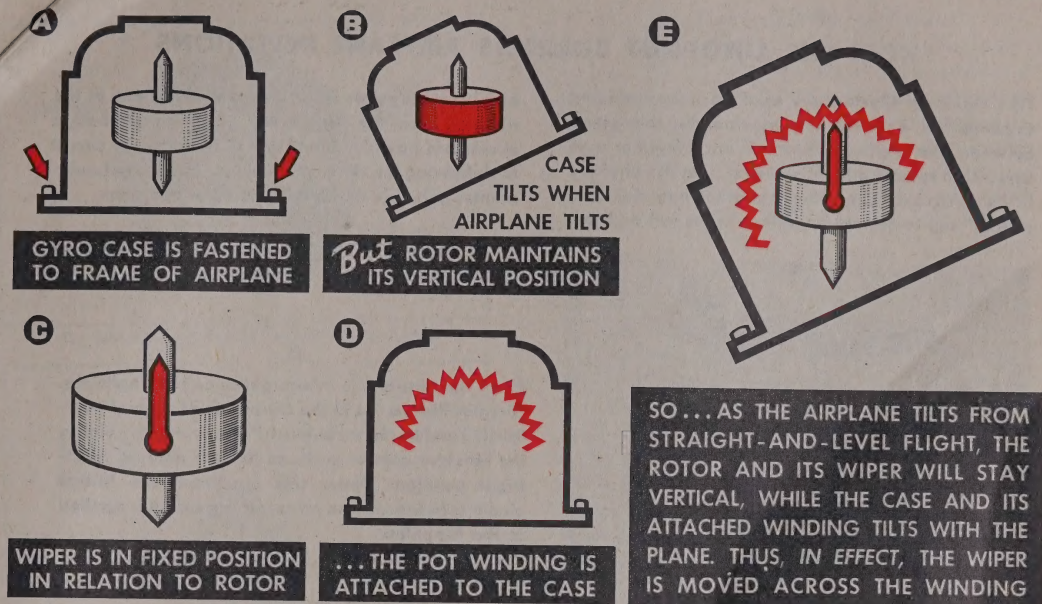


Fig. 4—How Airplane Deviations Affect the Vertical Flight Gyro

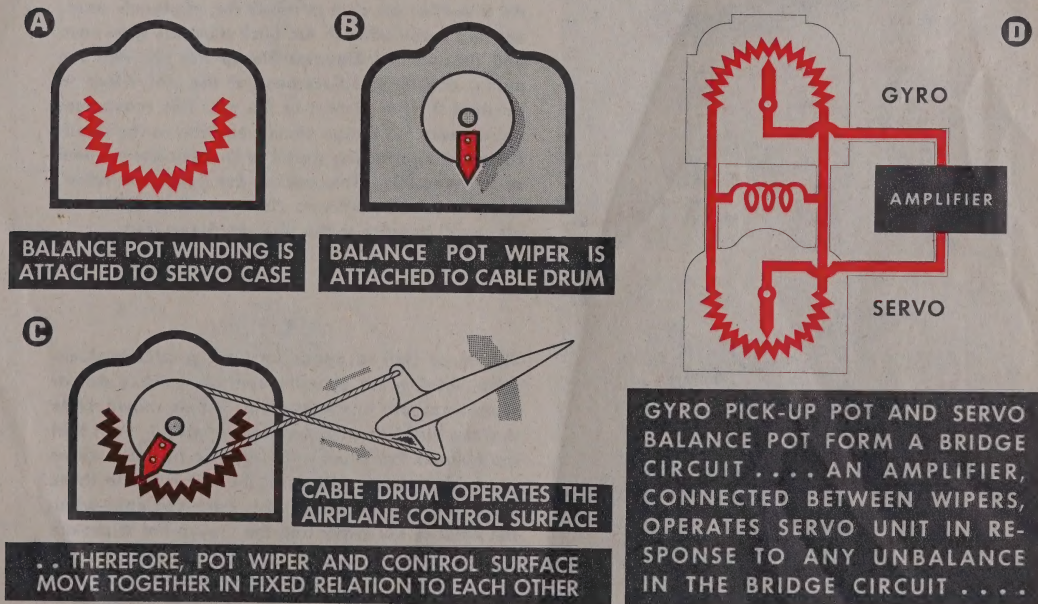
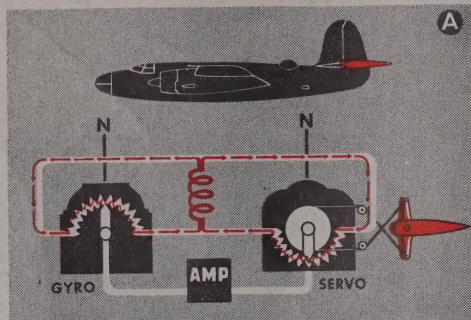


Fig. 5—How the Servo Units Balance Signals from the Gyro

HOW THE AUTOPILOT CORRECTS AIRPLANE DEVIATIONS

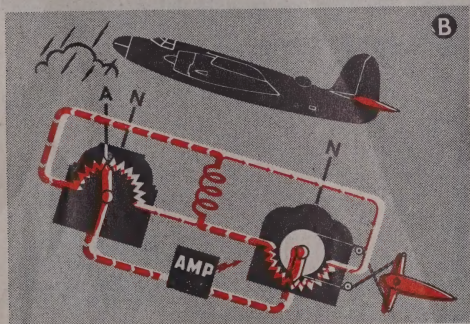
This series of illustrations and the accompanying explanations describe step-by-step the interaction between the Vertical Flight Gyro, Amplifier and Servo Unit resulting from a deviation of the airplane in its pitch axis only. The Autopilot operates in a similar way to correct deviations in the roll and turn

axis. The diagrams illustrate how deviations of the airplane cause the Flight Gyro to unbalance a bridge circuit and how the Servo Unit rebalances the circuit by following the Gyro movements. This is the fundamental principle of the C-1 Autopilot operation.



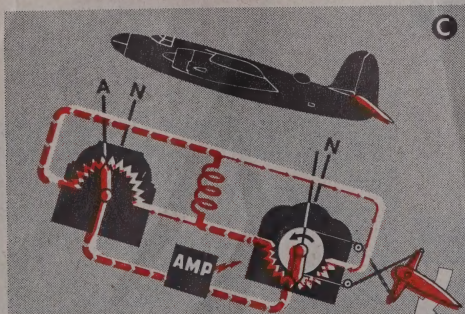
A

When the airplane is in straight-and-level flight, the Elevator Pickup Pot in the Gyro is at its normal position (N) and the Servo Balance Pot is centered, holding the elevator control surfaces in their normal, level-flight position. Under this condition, the bridge circuit is balanced and no correcting signal is applied to the Amplifier.



B

As a sudden air current raises the airplane's nose, causing a deviation in the pitch axis, the gyro case and its attached Elevator Pickup Pot tilt with the plane, causing displacement of the pot wiper to position A with respect to the pot. This movement unbalances the bridge circuit resulting in the application of a correcting signal to the elevator channel of the Amplifier. This causes the "down-elevator" relay in the Amplifier to close, sending a "down-elevator" impulse to the Elevator Servo Unit.



C

The Servo Unit responds by turning counter-clockwise, driving the elevator control surfaces downward by means of cables connected as shown. Note that the direction of Servo Unit rotation is such that the Balance Pot Wiper approaches a position where the bridge circuit will again be balanced. In these diagrams, the bridge circuit is balanced only when the Balance Pot Wiper and the Pickup Pot Wiper are parallel.

Fig. 6—How the Autopilot Corrects Airplane Deviations

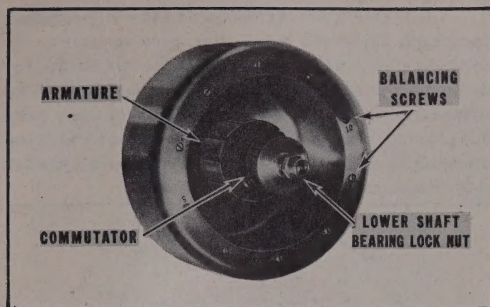


Fig. 12—Gyro Rotor and Armature Assembly

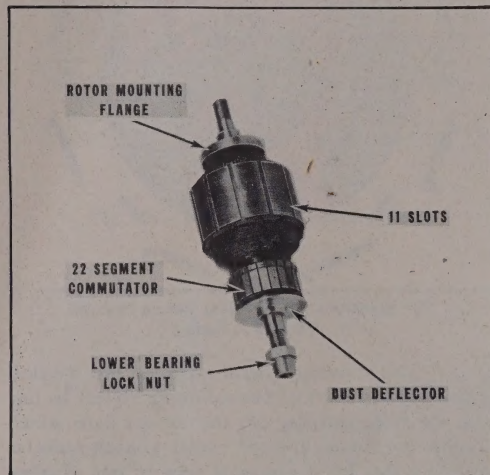


Fig. 13—Gyro Armature

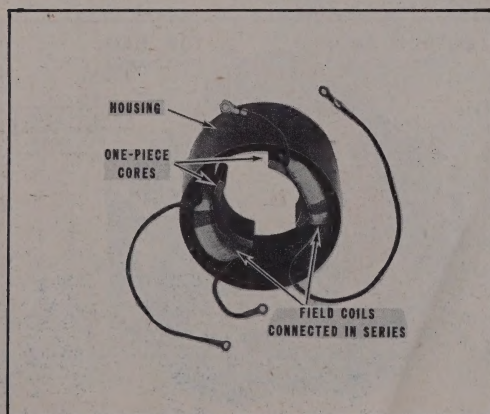


Fig. 14—Two-pole Field and Field Coils

(a) THE GYRO ROTOR ASSEMBLY

1. The heart of the Vertical Flight Gyro is the gyro rotor which is shown in Fig. 12. It consists of a cup-shaped flywheel with 20 small balancing screws (ten on each side) spaced evenly around its edge. It is firmly mounted on a small 8-ounce armature, shown in Fig. 13, which has an operating speed of approximately 7500 rpm. Note the dust-deflecting plate which prevents commutator dust from fouling the bearings.

2. This rotor assembly spins between ball bearings inside the gyro rotor case, shown in Fig. 15. A pair of field coils (Fig. 14) mounted in an iron housing energize two one-piece field magnets bolted to the housing. This stator assembly is fastened to the rotor case and fits into the space between the armature and the rotor.

3. The rotor case is suspended between ball bearings which permit the case to tilt freely around a horizontal axis. One of these bearings, called the "locked bearing," is rigidly mounted in the case; the other is free to slide a little in its socket to allow for uneven expansion of the rotor case due to temperature changes. This entire assembly, including the erecting gears and mechanism (to be described later), is shown in Fig. 16.

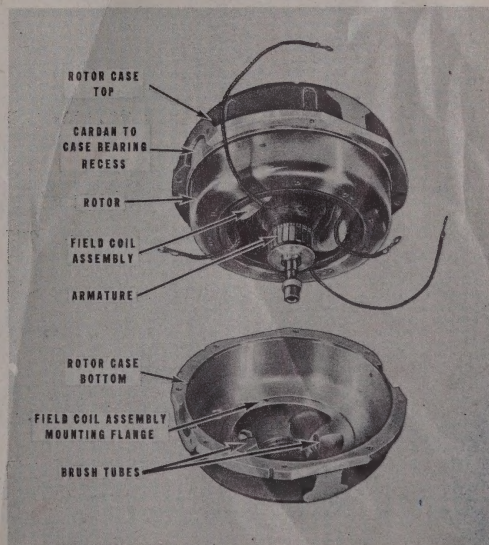


Fig. 15—Gyro Rotor and Rotor Case Assembly

(b) THE CARDAN RING —Fig. 17 shows the Cardan Ring assembly which, with the rotor case, makes up the universal-joint mounting of the gyroscope. The normal position of the Cardan Ring in the Vertical Flight Gyro is horizontal, but it is fitted with ball bearings at each side which permit it to rotate about the pitch axis of the airplane. Gudgeon pins (fore and aft) in the roll axis of the ring fit into the bearings of the rotor case, permitting the rotor and case to rotate around the roll axis of the airplane. Fig. 21 shows the complete assembly including the Erecting Bails and Counterbalance Guide Channel which will be described presently.

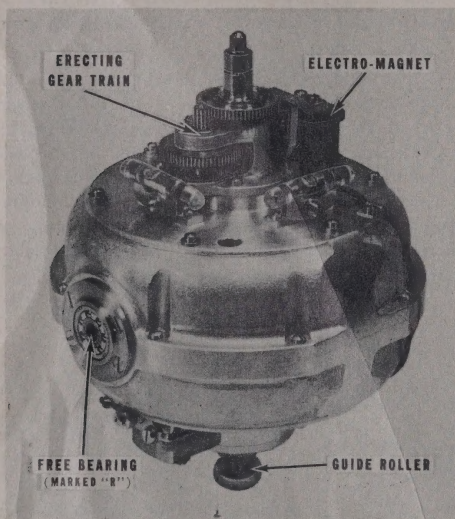


Fig. 16—Gyro Rotor and Case Assembly, closed

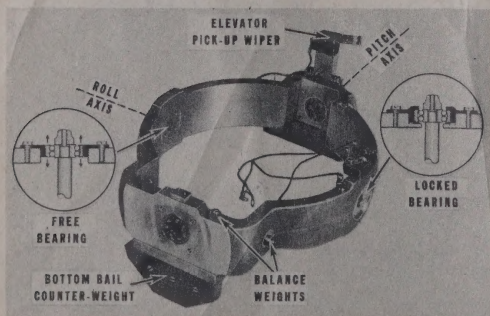


Fig. 17—Cardan Ring Assembly

(c) THE ERECTING SYSTEM —A preceding paragraph explained how a free gyro appears to tip end-over-end, due to the rotation of the earth. For this reason a free gyro is useless as a navigational instrument, but erecting systems have fortunately been devised to prevent this apparent precession by keeping the spindle of the gyro vertical to the earth's surface at all times, as shown in Fig. 18.

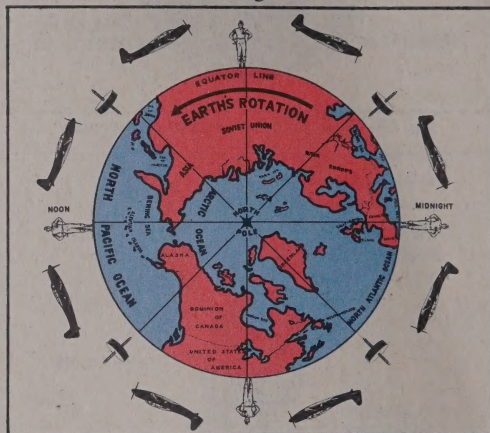


Fig. 18—Gyro with Erecting System remains Vertical to Earth

The erecting system used in the Vertical Flight Gyro consists of two spinning rollers in line with the rotor spindle, and two slotted bails which straddle the rollers at right angles to each other as shown in Fig. 19. A sectional view of one of these bails is shown in Fig. 20. Note cork inserts with which the slot is lined.

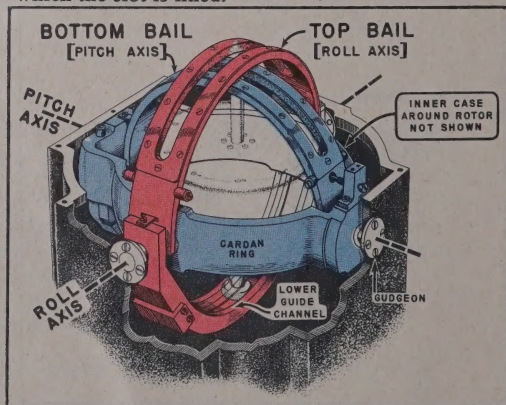


Fig. 19—Erecting Bails straddle rollers on Gyro Case

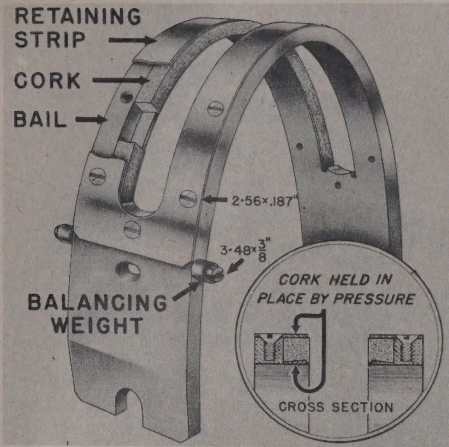


Fig. 20—Construction of an Erecting Bail

The rollers are driven by a gear train mechanism mounted on top of the rotor housing, as shown in Fig. 22 and 23. As may be seen in these illustrations, the gyro spindle or shaft has a small pinion at its top end which meshes with the large intermediate gear mounted to one side of the spindle. This large gear turns in ball bearings and drives the intermediate pinion through a common shaft. This pinion, in turn, meshes with the bottom roller gear, driving it in the same direction as the gyro rotor shaft, but at only $1/32$ the speed of the gyro rotor.

The bottom roller gear and attached bottom roller turn on a stationary spindle and are free to move up and down along the spindle for a short distance. Lugs on the top side of the bottom roller engage similar lugs on the bottom of the top roller just above it. Thus when the bottom roller is held upward by the spring-loaded clutch actuator, the two rollers spin together. However, when the lower roller is allowed to fall, it disengages from the top roller, and the top roller stops spinning.

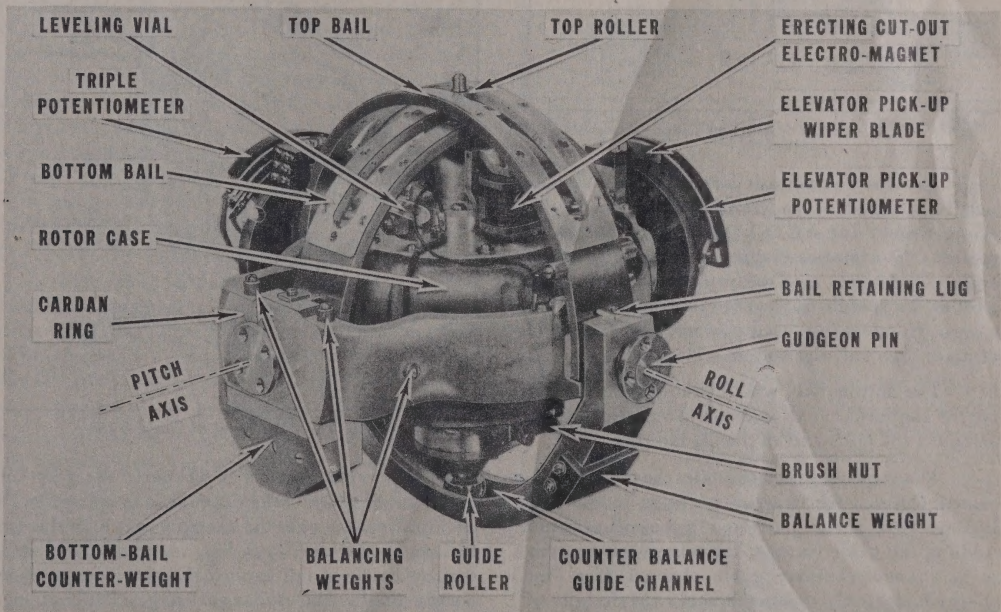


Fig. 21—Gyro Rotor Case, Cardan, and Erecting Mechanism

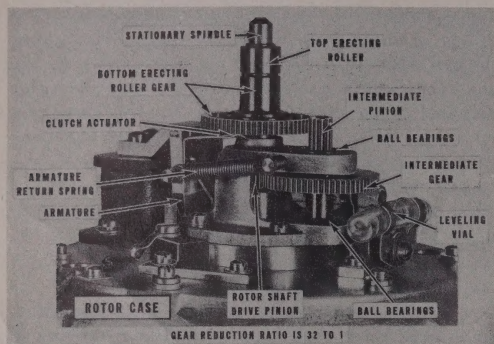


Fig. 22—Erecting Cutout Gear Train Assembly

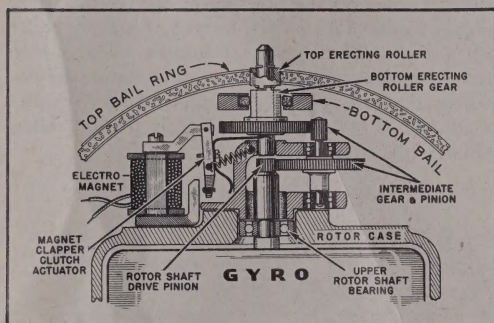


Fig. 23—Cross-section of Erecting Cutout Assembly

The clutch actuator is fastened to an armature which is operated by an electro-magnet called the Erecting Cutout (or E.C.O.). When this magnet is energized, the armature clapper is pulled toward it, allowing the bottom gear to drop and disengage the top roller. Thus both rollers are spinning all the time the gyro is operating except when the E.C.O. is energized; then only the bottom roller turns.

The bottom bail, which straddles the bottom roller, is supported at its ends on low friction sleeve bearings in the pitch axis of the cardan ring.

The top bail, which straddles the top roller, is mounted between low-friction bearings in the roll axis of the gyro housing. Pivoted in the roll axis and straddling the guide roller at the bottom of the gyro case is a counterbalance guide channel (See Fig. 21) which not only counterbalances the weight of the top erecting bail and other mechanism, but serves primarily to keep its attached pot wipers in a fixed relation to the position of the gyro rotor.

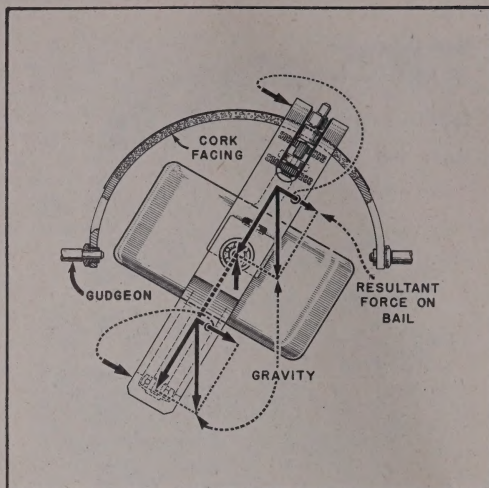


Fig. 24—Bail falls Against Roller when Gyro Tilts

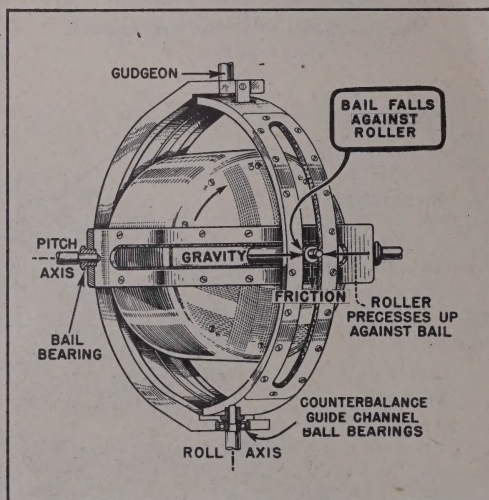


Fig. 25—Top View of Tilted Gyro

It can be seen that whenever the gyro tilts, one or both of the bails tilt with it as shown in Fig. 24. Considering only the example in which the gyro tilts on its roll axis, as in Fig. 25, it can be seen that the top bail will fall against the top roller, and the weight of the bail will apply a gravitational force against the top of the gyro spindle in the direction of tilt. This force alone would cause the gyro to precess along the slot in the bail, but no precession results

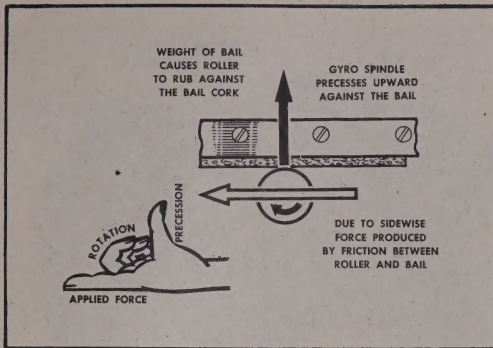


Fig. 26—Friction Between Roller and Bail Precesses Gyro Against the Bail

because the weight of the counterbalance guide channel applies an equal and opposite force to the bottom of the gyro spindle, thus neutralizing the precession tendency.

However, the top roller is spinning rapidly and its surface rubs against the cork insert of the bail, producing a *frictional* force in the direction of the slot, as shown in Fig. 26. This force, applied to the roller, causes the gyro to precess at right angles to the bail and against the force of gravity. Hence the gyro is made to precess back up to the vertical position. When the gyro is again vertical, the precession stops because the top bail no longer rides on the roller but vibrates back and forth, touching the roller first on one side and then on the other. The clearance between cork and roller is .018"-.022" to permit this vibration, whereas the clearance between counterbalance guide channel and its guide roller is held to the smallest practical value.

When the gyro tilts around its pitch axis, the bottom bail and bottom roller come into play in a similar way, but in this case the weight of the bottom bail is counterbalanced by a fixed weight on the underside of the cardan ring (Fig. 21).

Thus the two bails and their rollers maintain the gyro vertical with respect to the earth, irrespective of the airplane's deviations in its roll or pitch axis.

(d) ERECTING CUTOUT MECHANISM —

The erecting system just described introduces another factor which must be considered when the airplane deviates in its turn axis. It can be readily seen that whenever the airplane turns, the top bail will be thrown against the top roller by centrifugal force. If the top roller were spinning, it would rub against the

bail and produce a frictional force resulting in undesirable precession toward the center of the turn. This false erection would continue until the gyro has tilted to the position shown in Fig. 27 where the centrifugal force acting outward on the bail is balanced by the gravitational force acting inward on the bail. If the airplane were in a banked turn, as illustrated, the gyro would continually seek a position perpendicular to the floor of the airplane and therefore could not be used as an accurate vertical reference.

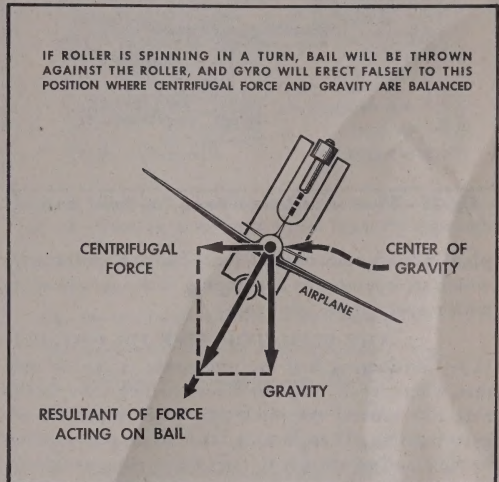


Fig. 27—Gyro Would Tilt in Turns if Roller Were Not Disengaged

In order to prevent this false erection during a turn, the erecting mechanism includes a cut-out magnet which is energized either by a switch in the Turn Control or a similar switch in the Directional Panel. Thus, whenever the Turn Control is operated or whenever the airplane's course deviation is appreciable, the erecting cut-out magnet disengages the top roller. When the top roller is not spinning, no frictional force is produced as the bail presses against the roller, and therefore no false erection takes place. Since the erecting bail and the counterbalance guide channel are of equal weight and with centers of gravity equidistant from their common pivot, the centrifugal force acting upon the erecting bail is balanced by an equal force acting upon the counterbalance guide channel as illustrated in Fig. 28.

(e) THE CONTROL MECHANISM—The vertical rigidity of the gyro is used as a reference for the operation of the Autopilot system. This is accom-

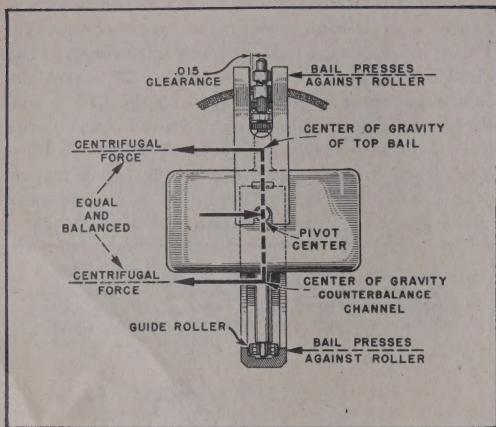


Fig. 28—Effect of Centrifugal Force, Top Roller Stopped

plished by a system of electrical pickup potentiometers which are operated by any tipping of the gyro housing with respect to the gyro rotor.

1. THE ELEVATOR PICK-UP POT (E.P. U.)—Considering first the pitch axis, it can be seen that, whenever the airplane dives or climbs, the cardan ring tilts around the pitch axis with respect to the gyro housing. Therefore by fastening a pot winding to the case and a wiper to the cardan ring, any deviation of the airplane in the pitch axis will be measured electrically by the pot. This "pitch axis" pot controls the operation of the elevator control surfaces and is therefore called the Elevator Pick-up Pot (Fig. 30). Its location can be seen in Figs. 29, 36 and 37. Its electrical connections are shown in the Internal Wiring Diagram, Fig. 34.

2. THE TRIPLE POT ASSEMBLY—Deviations in the pitch axis can be corrected by operation of only the elevator control surfaces, but deviations in the roll axis, particularly during turns made from the Turn Control, require the operation of all three control surfaces—ailerons, rudder and elevator.

The ailerons and rudder are used simultaneously to "turn and bank" the airplane back to its level flight position. A little "up-elevator" is also required to maintain altitude during the turn. Therefore, three pot windings are attached to the gyro case on the roll axis, and three individual wipers are mounted on a bakelite block fastened to one end of the counterbalance guide channel, which tilts with the gyro rotor in the roll axis. The guide channel is used to support the triple pot wipers rather than the top erecting bail

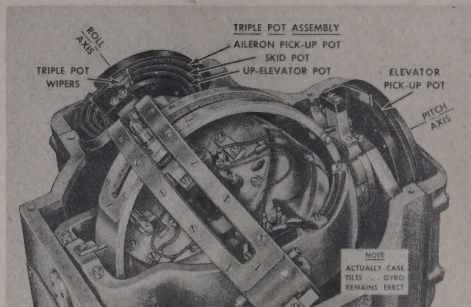


Fig. 29—Pickup Pots in Vertical Flight Gyro

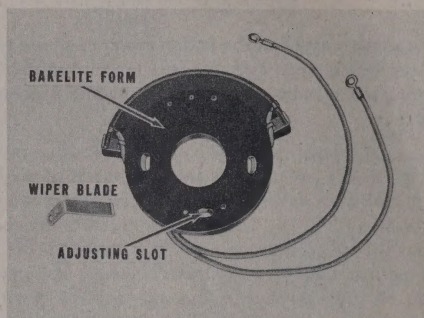


Fig. 30—Elevator Pickup Pot and Wiper

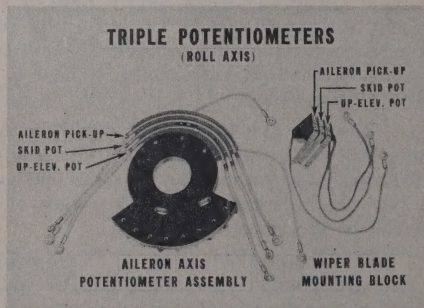


Fig. 31—Triple Pot Assembly

because the bail is comparatively loose and subject to rapid vibration. The Triple Pot is shown in Fig. 31.

The outer or upper pot in this assembly is the Aileron Pick-up Pot which controls the Aileron Servo Unit. The middle pot is the Rudder Compensa-

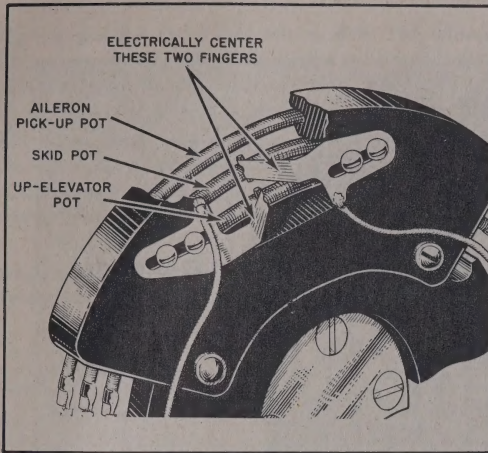


Fig. 32—Center Taps on Triple Pot Assembly

tion or Skid Pot which applies rudder control to produce a coordinated turn whenever the airplane banks. The lower or inner pot is the Up-Elevator Pot which applies up-elevator control surface to maintain altitude during turns.

The Aileron Pick-up Pot contains no center tap or dead spot, but center taps are used on the Skid Pot and Up-elevator Pot. In the current (Type G1021B) Vertical Flight Gyro both these pots are center tapped by adjustable contact fingers as shown in Fig. 32. It is important that these center tap contact fingers be adjusted to the electrical center of the pot winding and that the pot assembly be centered by the elongated hole adjustment (Fig. 31) so the center tap fingers are opposite the pot wipers when the gyro is perpendicular to the floor of the airplane. Earlier models, Type G1021A, employed dead spots which were produced by two interconnected adjustable contact fingers as shown in Fig. 33. These dead spots "shorted" out a section of the resistance so the pot wiper could move a limited distance either side of center without introducing a correcting signal to the rudder or elevator Servo units. Thus, small roll axis deviations of the airplane were corrected by the application of ailerons only. With the introduction of the current type Directional Panel employing dual banking pots (Section 2, par. 2 c) the dead spots in the Vertical Flight Gyro were no longer necessary and were replaced by center taps.

Fig. 34 is an internal wiring diagram showing all the connections in the Vertical Flight Gyro. Note that dead spots are indicated on the Skid Pot and

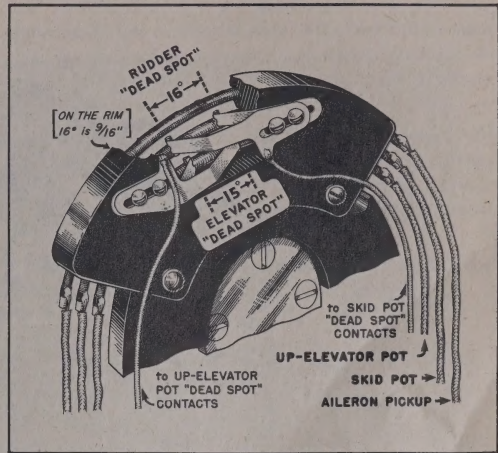


Fig. 33—Dead Spots on Early Model Triple Pot Assembly

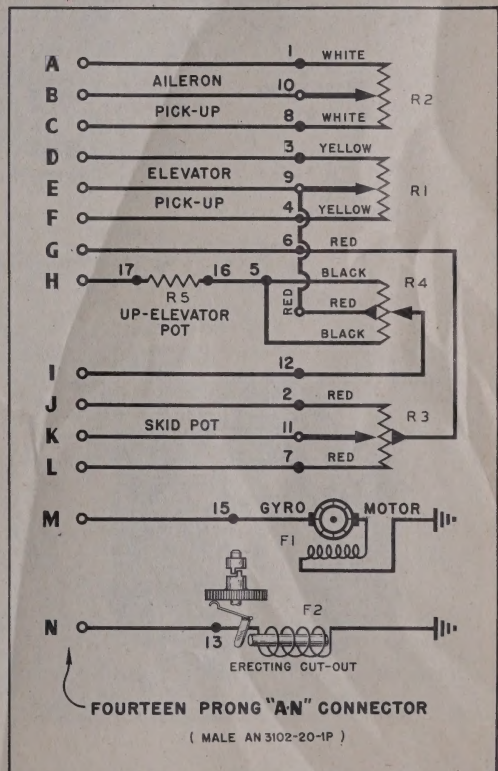


Fig. 34—Schematic Wiring Diagram, Vertical Flight Gyro

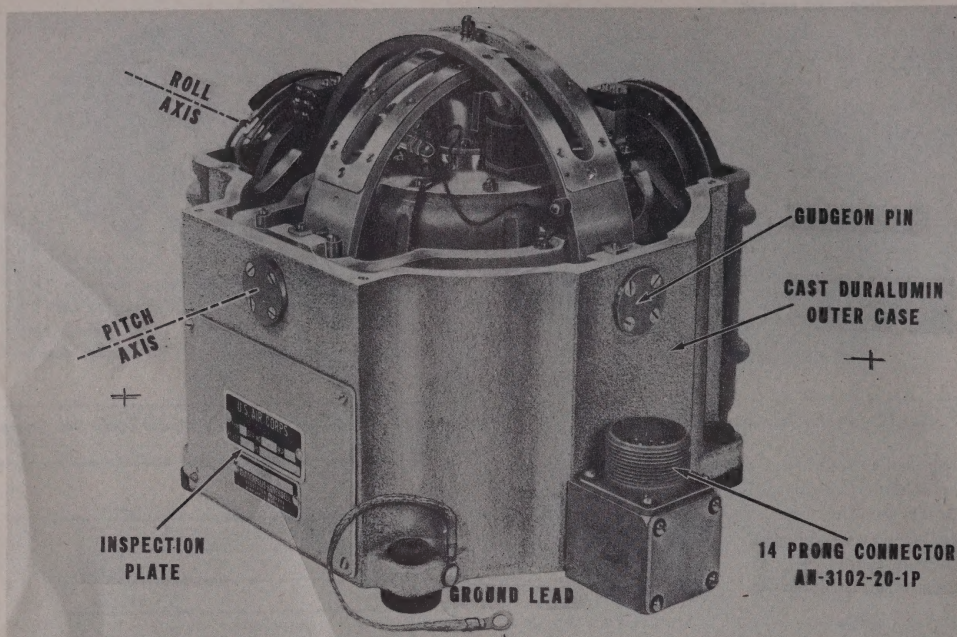


Fig. 35—Vertical Flight Gyro, cover removed

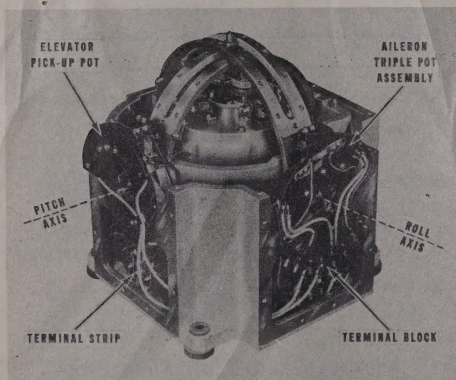


Fig. 36—Vertical Flight Gyro, cover removed

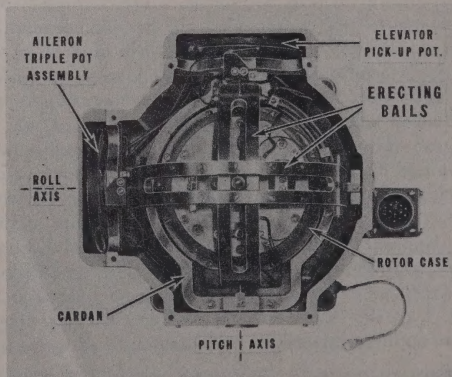


Fig. 37—Vertical Flight Gyro, top view

Up-Elevator Pot as on the early models. The wiring of the later model units is exactly the same except that center taps are substituted for these dead spots.

(f) CASE AND COVER—The complete Vertical Flight Gyro assembly is mounted in a cast duralumin case. It has a large cover made of the same material which serves to seal the delicate mechanism against dust and moisture.

Fig. 35 illustrates the complete unit with top cover removed. Note the 14-prong A-N connector receptacle in the lower right hand corner and the

inspection plate on the left side. This inspection plate provides convenient access to a terminal block inside and to the lower parts of the unit without the necessity of removing the unit from its mounting.

Fig. 36 is a view of the Vertical Flight Gyro from the opposite corner with potentiometer covers removed to show the backs of the potentiometer assemblies. Notice the rubber grommet shock mounts at the corners of the base.

Fig. 37 is a top view of the Gyro showing the relationship of cardan ring and erecting bails.

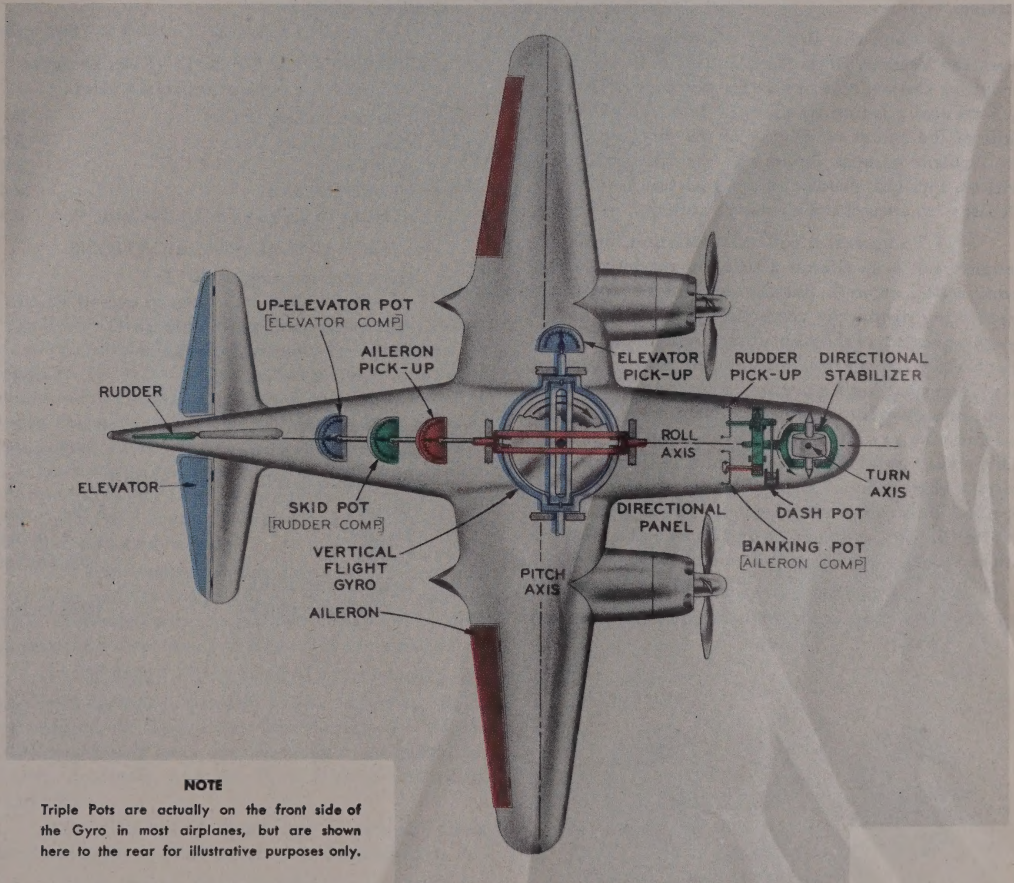


Fig. 38—Schematic Drawing of Vertical Flight Gyro and Directional Stabilizer Showing Position of Pots

(3) ACTION OF THE VERTICAL FLIGHT GYRO IN THE AIRPLANE

(a) Fig. 38 is a top view of an airplane showing two enlarged gyros in their approximate locations with respect to the flight control axes of the airplane. The gyro in the nose of the airplane represents the Directional Stabilizer which is fully described on following pages. The gyro near the center of the airplane, with its elevator pickup pot in the pitch axis and its aileron pickup pot, skid pot and up-elevator pot in the roll axis, is the Vertical Flight Gyro. Note that each of these pots is colored red, blue or green to correspond with its respective airfoil control surface.

(b) When the airplane is flying straight-and-level, the Vertical Flight Gyro and its pots are in the positions shown. Notice that the pot wipers are held in a vertical position by the spindle of the gyro. If a shift of the center of gravity of the airplane causes the airplane to nose down, the elevator pickup pot will tilt forward, producing a signal calling for "up-elevator" to correct the airplane's attitude.

(c) To correct a roll axis deviation, however, requires not only aileron action but rudder and elevator action as well. For example, if the airplane's right wing drops, the correction is made by downward movement of the right aileron and upward movement of the left aileron. Since the air below the wing is at somewhat higher pressure than the air above the wing, the down-moving right aileron produces considerably more drag than the up-moving left aileron. This makes the airplane tend to turn to the right during the correction unless compensating left rudder is applied. This compensating rudder action is produced by the skid pot which is operated in unison with the aileron pickup pot in the roll axis of the airplane.

(d) In a similar way, the up-elevator pot applies up-elevator whenever the airplane rolls to either side

in order to compensate for the loss of lifting force which occurs during the roll.

(e) It is important to understand that the Autopilot applies corrective control as soon as the airplane begins to swerve from its straight-and-level flight, and that corrective action of all three control surfaces occurs simultaneously.

(4) SPECIFICATIONS

(a) GYRO

Weight of rotor	5 lbs.
Gyro running current (26 volts D.C.)	0.65 amps
Speed of rotor (after 15 minutes)	7000 to 7800 rpm

(b) RESISTANCE OF POTS (Refer to figure 142A for table of resistance values.)

Elevator Pickup Pot	R1
Aileron Pickup Pot	R2
Skid Pot	R3
Up-Elevator Pot	R4
Resistor in series with Up-Elevator Pot	R5

(c) MECHANICAL SPECIFICATIONS

Gyro erection time at 70° F. (21° C.)	not to exceed 12 min.
Allowable level vial bubble travel	1.4°
Ratio, erecting roller speed to gyro speed	1 to 32
Clearance between roller and bail cork	.018''-.022''
Motor brush tension	3-3½ ozs.

(d) WEIGHT AND DIMENSIONS

Weight	18 lbs. 4 ozs.
Height	8 inches
Width	8 ⁵ / ₁₆ inches
Length (including AN receptacle)	10 ³ / ₈ inches

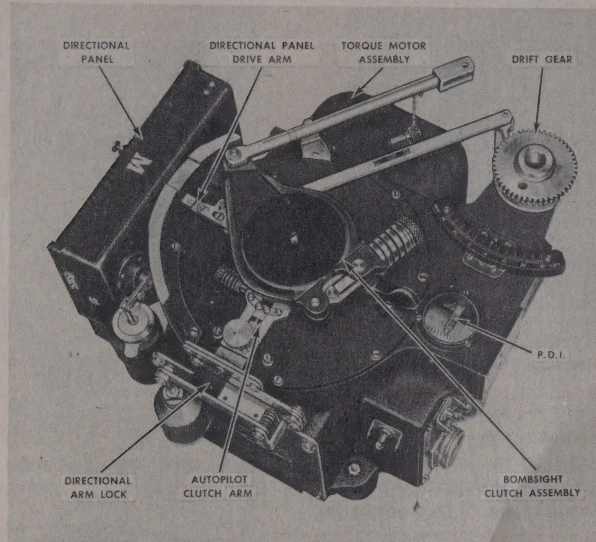


Fig. 39—Directional Stabilizer (Bombardier's Turn Knob Not Shown)

b. DIRECTIONAL STABILIZER—The Directional Stabilizer, Fig. 39, is located in the nose of the airplane. Its flight control function is to detect and measure directional deviations of the airplane, and to move the slide of the attached Directional Panel in the proper direction proportional to the deviation. The pots within the Directional Panel transform this motion into electrical signals which control the operation of the C-1 Autopilot System to hold the airplane on an established heading.

Like the Vertical Flight Gyro, the Directional Stabilizer utilizes a gyroscope, but in this unit the gyro is mounted with its spin axis horizontal in order to provide a directional reference for the airplane.

(1) DETAILS OF CONSTRUCTION—The Directional Stabilizer consists of the following major assemblies: the Gyro Rotor and Cardan, the Torque Motor and gear train, the Bombsight and Autopilot Clutch Assembly, and the Pilot Director Actuating Assembly.

The Directional Panel and Directional Arm Lock are separate units attached to the Stabilizer.

(a) ROTOR AND CARDAN ASSEMBLY

1. The Gyro Rotor consists of a cup-shaped flywheel mounted on the same shaft with the motor armature. This assembly is supported on ball-bearings

within a housing called the gyro case. Two field coils are fastened to the inside of the gyro case in such a way that they surround the armature in the space between the armature and the gyro rotor proper. This assembly is illustrated in Fig. 40. The complete

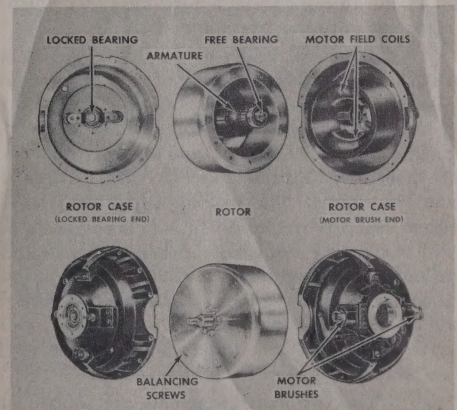


Fig. 40—The Rotor and Rotor Case Assembly, Inner and Outer Views

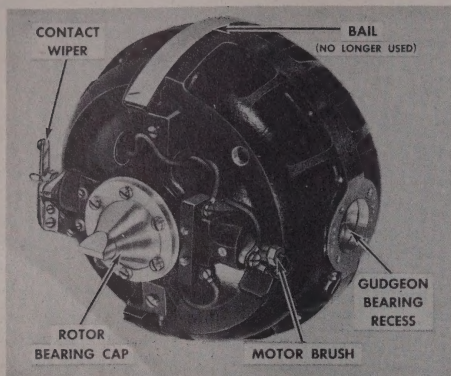


Fig. 41—Rotor Case (Closed)

unit, Fig. 41, forms a simple d-c motor in which the armature attached to the rotor revolves between fixed field coils mounted in the gyro case. The commutator brushes are held in brush tubes which are a part of the gyro case. The normal speed of this motor is 7500 to 8000 rpm.

2. Fig. 42 shows the Cardan which supports the Rotor Case assembly described above. The Cardan is mounted vertically within the Stabilizer housing on ball bearings at both the upper and lower ends of the assembly, thus permitting the Cardan to rotate about an axis perpendicular to the floor of the airplane. As shown in Fig. 43, the gyro rotor case is mounted in the Cardan between horizontal gudgeon bearings. This arrangement permits the case and enclosed rotor to pivot about a horizontal axis which is at right angles to the gyro rotor axis.

3. Fastened rigidly to the upper part of the Cardan is an assembly consisting of two resistors, four copper slip rings, and a large ring gear. In addition, a bakelite block with four flat silver-faced copper segments is mounted on one side of the Cardan ring. This assembly, illustrated in Fig. 42, is called the contact assembly. The pick-up wiper mounted on the gyro case (illustrated in Fig. 44) is so placed that it will rest on the insulator between the two middle segments of the sector block when the gyro spindle is at right angles to the Cardan axis, parallel with the floor of the airplane. When the gyro tips on its gudgeon bearings, the contact wiper moves up or down to contact one of the four segments.

The two outer segments are individually connected to two of the four copper slip rings mounted on the Cardan shaft just below its top bearing. The two inner segments are connected respectively through

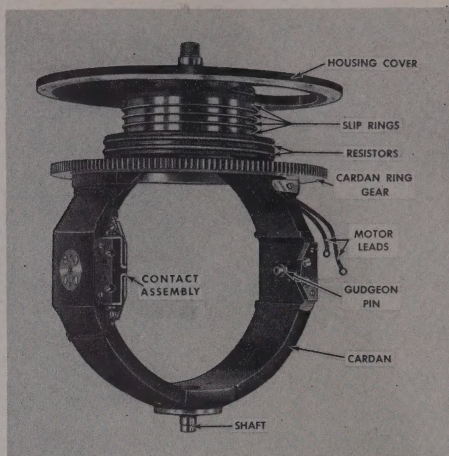


Fig. 42—Cardan Assembly

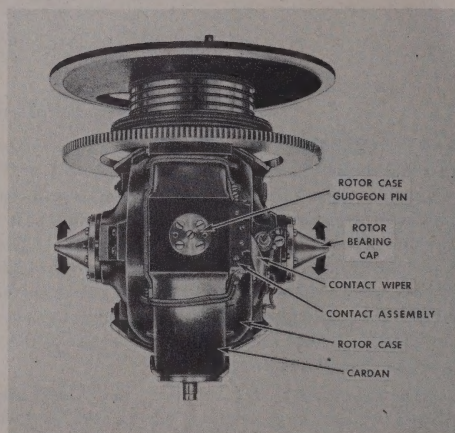


Fig. 43—Cardan Assembly with Rotor Case Mounted in Position

the two lower resistances to the same two slip rings. The other two slip rings are connected by flexible leads to the motor in the gyro rotor case. (See Fig. 55.)

(b) THE TORQUE MOTOR ASSEMBLY

1. The Torque Motor Assembly, mounted on the forward side of the Stabilizer, is shown in Fig. 45. It consists of a small shunt-wound motor which drives a train of gears through two magnetically operated clutches which control the direction of rotation of the gear train. The speed of the motor is

4. The tension of the Autopilot clutch is adjusted at 10 to 12 pounds by a knurled nut shown in Fig. 50. The clutch tension must be great enough to insure that any corrective movements of the gyro cardan assembly with respect to the case will be transmitted without slippage to the Directional Panel. But the tension must not be so great that locking of the Directional Arm will keep the Cardan from turning when it is being driven by the Torque Motor.

5. On the top of the Autopilot clutch collar is a small pin to which is fastened the Autopilot connecting arm. The other end of this arm connects to the drift gear clutch, (Fig. 51), which holds the drift gear and PDI pot wiper in fixed relation to the Cardan assembly. Proper tension of the drift gear clutch is six to eight lbs.

(d) PILOT DIRECTOR ACTUATING ASSEMBLY

1. The Pilot Director Actuating Assembly consists of a pot winding and wiper, as illustrated in Fig. 51. The wiper is fastened to the drift gear clutch

which is operated by the Autopilot connecting arm described above. Thus, when the Autopilot clutch is engaged, any motion of the Cardan with respect to the Stabilizer housing will result in movement of the PDI pot wiper across the PDI pot. The wiper is formed in the shape of a pointer and indicates on an adjacent scale the amount and direction of any deviation in the airplane's heading.

2. The PDI pot winding is supplied with direct current from the airplane's battery. Any displacement of the wiper from center of the winding produces a voltage between the wiper and a center tap on the winding. The magnitude and polarity of this voltage is measured by the Pilot Director Indicator or PDI on the pilot's instrument panel. The pointer of this instrument, therefore, follows the movements of the Autopilot clutch and indicates to the pilot the direction and amount of any course correction desired by the bombardier. When engaging the Autopilot system the pilot can tell when the Directional Panel is centered by watching the PDI. The PDI circuit is shown in Fig. 52.

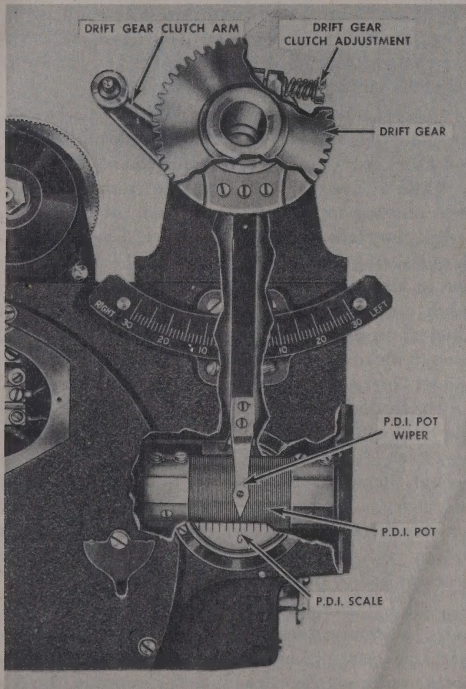


Fig. 51—P. D. I. Pot and Drift Gear Clutch

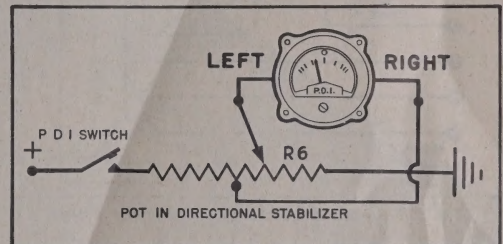


Fig. 52—P. D. I. Circuit

(e) INTERNAL WIRING CONNECTIONS

The various parts of the Directional Stabilizer are electrically interconnected, as shown by the internal wiring diagram (Fig. 53). As may be seen, the Stabilizer switch (marked STAB, Fig. 56) supplies current to the gyro motor through the two lower slip rings. The torque motor switch (marked SERVO) closes circuits to the PDI pot and the clutch magnets as well as to the torque motor itself. The clutch magnets, however, are not energized until their individual circuits are completed by the engagement of the pick-up wiper on the rotor case with the corresponding clutch contact sectors. Note that the R7 resistance is connected between the inner sector and outer sector on each side of the sector block. These resistances reduce the voltages applied to the clutch magnets, when the inner sectors are contacted by the wiper, to approximately half the voltage that is applied when the outer sectors are contacted.

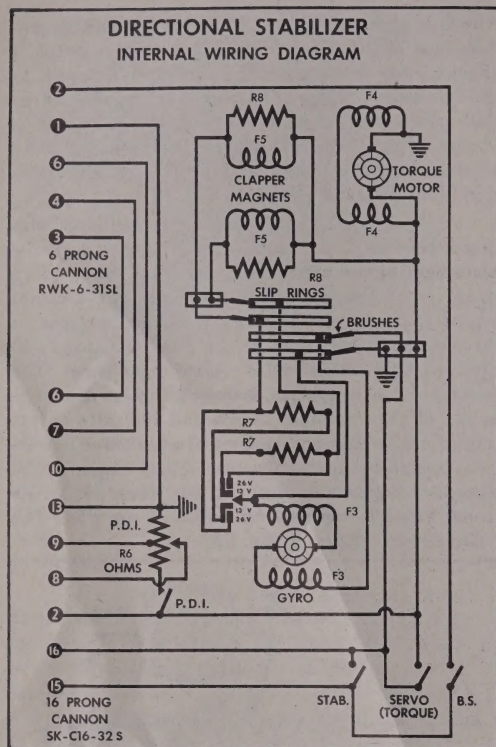


Fig. 53—Directional Stabilizer—Schematic Wiring

(2) FUNCTION OF DIRECTIONAL GYRO AND TORQUE MOTOR ASSEMBLY

(a) Apparent precession, which was explained with reference to a vertical gyro in paragraph 2a of this section, is also encountered in the use of a horizontal gyro. Fig. 54 illustrates how such a gyro, spinning on a horizontal axis at 6:00 A.M. would be vertical at noon and would turn end over end in 24 hours. Actually, of course, the gyro has not tipped at all; the earth has merely changed its position relative to the gyro rotor. Nevertheless, since airplane flight must be controlled with respect to geographic locations on the earth's surface, it is necessary that an aligning system be used to maintain the gyro axis parallel to the earth's surface, or approximately so. This is one function of the Torque Motor Assembly. Actually, for the sake of mechanical rigidity and accuracy, the gyro rotor axis is kept parallel with the airplane's floor which, in straight-and-level flight, is essentially horizontal.



Fig. 54—Earth's Rotation does not affect Gyro's Position

(b) The primary function of the Torque Motor Assembly is to counteract any external forces applied to the Cardan which would tend to precess the gyro away from its normal "horizontal" position. By so doing, the torque motor, in effect, gives the small gyro rotor in the Stabilizer the same rigidity or inertia as a much larger and heavier gyro.

(c) Referring to Fig. 55, it is apparent that clutch gears D and E are driven in opposite directions by the torque motor through intermediate gears B and C. When a force is applied to the Autopilot clutch drum tending to turn the sector side of the Cardan toward the right, the resulting upward precession of the gyro brings the pick-up wiper attached to the rotor case in contact with the first upper segment of the clutch contact sector. A tilt of only one degree is sufficient to make this contact, completing a circuit through the lower resistance and the right-hand clutch magnet. Energizing this magnet raises the corresponding clutch disc against the cork surface on the under side of clutch gear E. The frictional force applied to the clutch disc F by the clutch gear is transmitted through intermediate gears H and I to the cardan ring gear, as indicated by the dotted arrows. Notice that this force tends to turn the Cardan and rotor to the left or in the opposite direction to the original force applied to the Autopilot clutch drum.

(d) It is important to remember that the torque motor assembly does not actually drive the cardan gear. It merely applies a force opposite to any external forces acting on the Cardan, as for example, the frictional force exerted by the Autopilot clutch on the Cardan when the airplane is turned with the Direc-

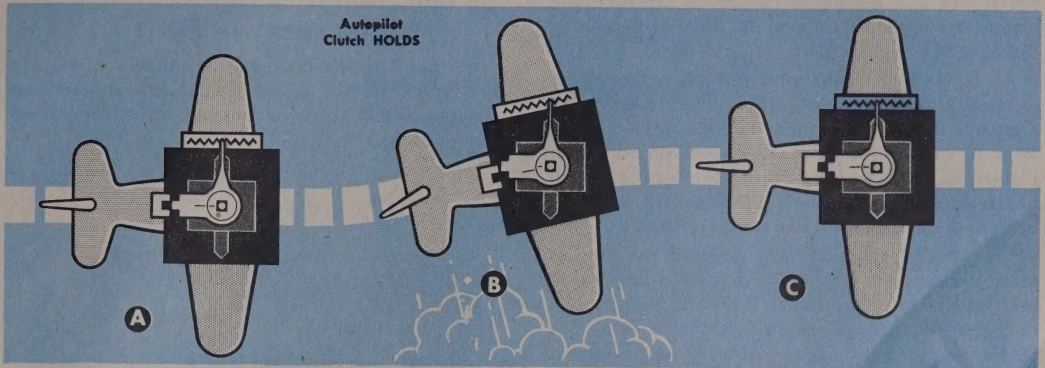


Fig. 57—Operation of the Directional Panel

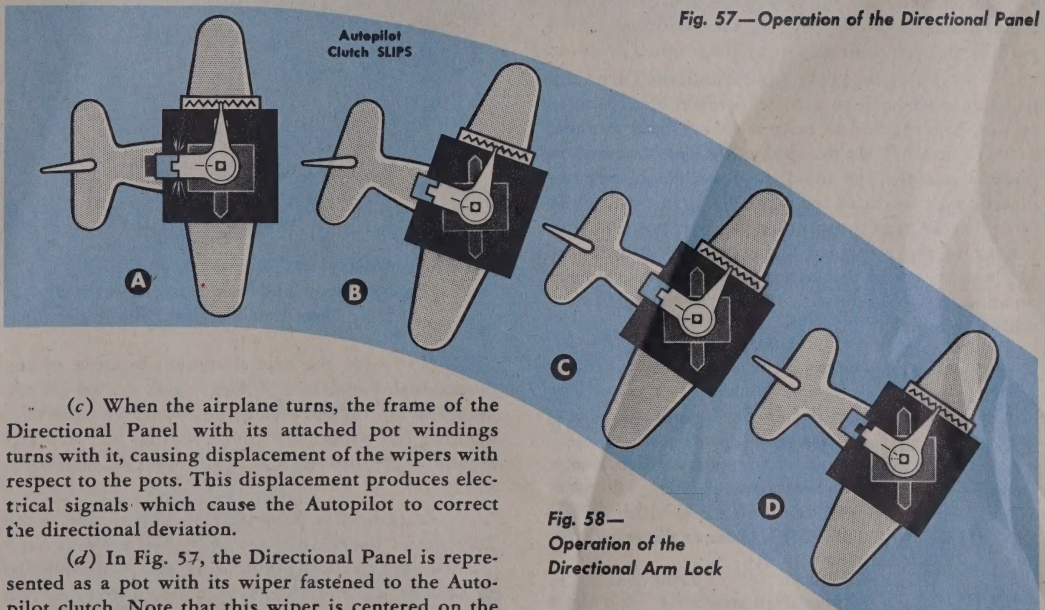


Fig. 58—
Operation of the
Directional Arm Lock

(c) When the airplane turns, the frame of the Directional Panel with its attached pot windings turns with it, causing displacement of the wipers with respect to the pots. This displacement produces electrical signals which cause the Autopilot to correct the directional deviation.

(d) In Fig. 57, the Directional Panel is represented as a pot with its wiper fastened to the Autopilot clutch. Note that this wiper is centered on the pot when the airplane is flying straight on a given heading, as at position A. However, when abrupt air currents change the airplane heading, as at B, the Stabilizer case and attached pot winding (Directional Panel) turn with the plane while the wiper is held in position by the rotor. The resulting displacement of the pots applies corrective voltage signals to other units of the Autopilot system which operate the rudder and ailerons of the airplane to return the airplane to its original heading at position C. At this point, the airplane has realigned itself with the gyro rotor, and the wiper is again centered on the pot.

(4) FUNCTION OF DIRECTIONAL ARM LOCK

(a) The Directional Arm Lock is actually a separate unit of the system which will be described in subsequent paragraphs. Nevertheless, it functions as a part of the Stabilizer and must therefore be introduced in this discussion.

(b) The Directional Arm Lock is a solenoid-operated clamp mounted on the rear side of the Stabilizer. When closed, it holds the Autopilot clutch in fixed relation to the Stabilizer case. In Figs. 57 and 58 the Directional Arm Lock is represented by the

square key and keyway at the left of the Autopilot clutch. During normal operation, the lock is open or disengaged as in Fig. 57.

(c) In Fig. 58, the pilot of the airplane desired to change the airplane's heading at position A. He applied a signal calling for rudder and aileron movement by turning his Turn Control knob (to be explained later). The Turn Control includes a switch which automatically closes the Directional Arm Lock before any rudder signal can be introduced.

(d) The resulting movement of the control surfaces causes the airplane to turn as in position B, but this time the Directional Panel can not respond to correct the turn because the Directional Arm Lock forces the Autopilot clutch collar to turn with the airplane, thereby preventing displacement of the Directional Panel pots. Slippage of the Autopilot clutch permits the gyro rotor to maintain its original position.

(e) This slippage continues until the Turn Control is turned back to zero to bring the airplane to its new heading and to restore a level flight attitude, as in position C. At this point the Directional Arm Lock is released and the Directional Panel resumes directional control of the airplane, as in position D. Note that the gyro rotor is now in a new position with respect to the airplane. The gyro will control the airplane as well in this new position as in its former position, provided the axis of the gyro remains essentially horizontal.

(5) SPECIFICATIONS

(a) GYRO

Rotor Speed	7900 rpm $\pm 5\%$
Current (after 10 min. run)	not to exceed 1 amp
Voltage requirement	26 volts
Brush Tension	4 to 5 ozs.

(b) TORQUE MOTOR (refer to figure 142A for resistance values.)

Armature Speed	4200 rpm $\pm 5\%$
Current (gear train attached)	0.6 amps
Brush Tension	3.5 to 4 ozs.
Resistance of Magnet Coils	F5
Resistance of Series Resistors	R7
Resistance of Shunt Resistors	R8
Clutch Disc Clearance	1/32 inch
Clearance, Magnet to Armature (clutch engaged)	1/32 inch

(c) CLUTCH TENSIONS

Bombsight Clutch	18 to 24 lbs.
Autopilot Clutch	10 to 12 lbs.
Drift Gear Clutch	6 to 8 lbs.

(d) WEIGHT (less Directional Panel and Directional Arm Lock) 39 lbs. 2 ozs.

c. DIRECTIONAL PANEL

(1) ARRANGEMENT OF PARTS

(a) The Directional Panel shown in Fig. 59 is mounted on the side of the Directional Stabilizer. Its primary function is to control the airplane's direction of flight.

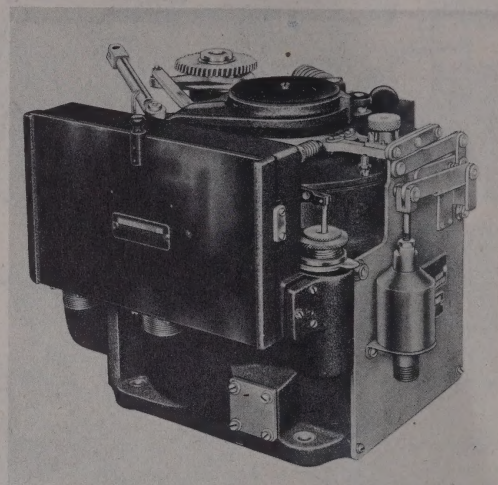


Fig. 59—Directional Panel mounted on the Directional Stabilizer

(b) Inside the cast aluminum housing of the Directional Panel is a sliding block on which are mounted the rudder pickup pot wiper and the dual banking pot wipers. The pot windings are mounted rigidly to the inside back of the housing, as shown in Fig. 60.

(c) The slide is moved from side to side by the Directional Panel drive arm, which extends through a slot in the back of the housing into a hole drilled into the back of the slide. See Fig. 61. Since the Directional Panel drive arm is an extension of the Autopilot clutch on the Directional Stabilizer, any change in the airplane's direction moves the slide and its attached pot wipers across the pots attached to the Directional Panel.

(d) Above the dual banking pots is a spring-leaf switch which is operated by cams attached to the Directional Panel slide. The operating cams are so spaced that whenever the slide is moved $\frac{1}{8}$ " or more in either direction from center, the switch will close a circuit which energizes the erecting cutout magnet in the Vertical Flight Gyro.

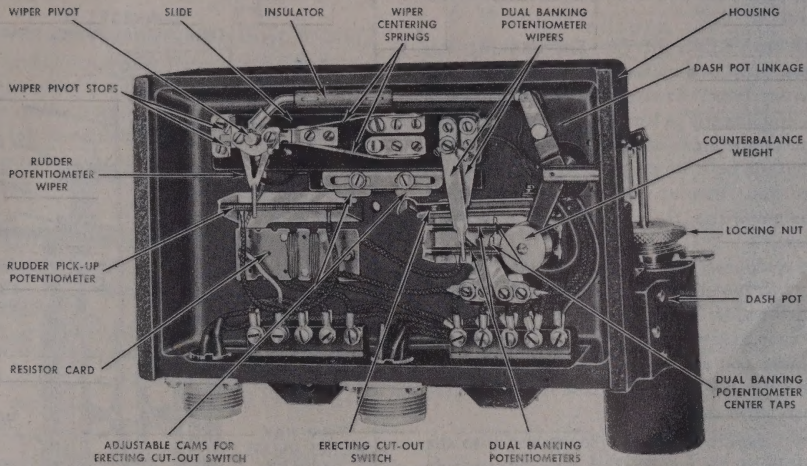


Fig. 60—Internal view of the Directional Panel (Type G1005B with Dual Banking Pots)

(e) Immediately below the rudder pickup pot is a resistor card which is a part of the dual banking pot circuit.

(f) Fastened to one end of the Directional Panel is a dashpot which serves a special function explained in the following paragraphs.

(2) THE RUDDER PICK-UP POT—The Rudder Pot wiper is mounted to the slide on a pivot. It has its upper end linked to the oil-filled dashpot by means of a horizontal bar and two crank levers connected by a shaft which passes through the back of the case.

It can be seen from examination of Fig. 60 that when the top of the Rudder pot wiper is restrained by the dashpot and linkage, any movement of the slide will cause the wiper to rotate on its pivot with a greater movement of its lower end along the pot. This rotation is opposed by a pair of leaf springs which tend to center the wiper. When the slide movement stops, the springs recenter the wiper, bringing it back to its vertical position. Two stops attached to the slide limit the amount of rotation. (See Fig. 60).

When the airplane's directional deviation is smooth and gradual, the restraining effect of the dashpot will be insufficient to deflect the springs; therefore the wiper will not pivot, and its displacement will be proportional to the deviation. On the other hand, when the deviation is sudden or abrupt, the restraining effect of the dashpot will be greater and will therefore overpower the springs. This causes rotation of the wiper, resulting in extra movement of the wiper tip proportional to the abruptness or velocity of the deviation. This action insures that sudden deviations will instantly result in a stronger correcting signal to the Amplifier, so that greater rudder correction will be applied to more quickly arrest the deviation than

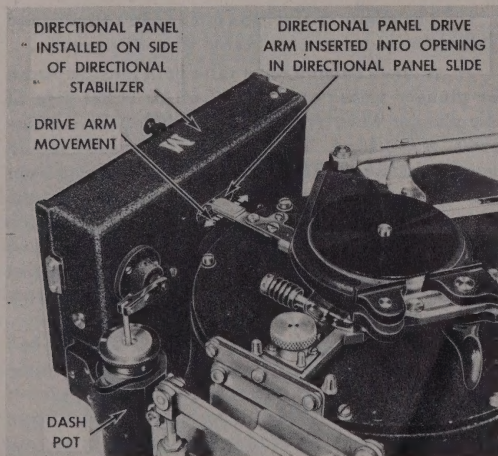


Fig. 61—The Directional Panel is operated by the Autopilot Clutch through the Directional Panel Drive Arm

would be possible without this mechanism. The result is greater flight stability and extremely accurate directional control.

(3) **THE BANKING POTS**—The Banking Pot assembly consists of two center-tapped pots mounted on a common bracket. The two pot wipers are mounted on the slide, one directly in line with the other. When the slide is at the mid-point or straight-course position, each wiper will be on the exact electrical center of its center-tapped pot. Since no voltage signal is picked up under this condition, the ailerons will be in their trim positions.

When a course deviation is detected by the directional gyro, the slide will move and the rudder pot will cause rudder movement to be introduced. At the same time, the two banking wipers will move across their pots and will introduce enough Aileron movement to correctly bank the plane for the degree of course correction required.

The two banking pots are connected into the bridge circuit in such a manner that they will provide aileron action for even small amounts of airplane deviation. They are also designed to prevent the airplane from overshooting its correct-course, level-flight position while it is being rapidly returned from a large deviation.

The arrangement and interconnection of the dual banking pots and their series resistors are such that *large* deviations of the airplane produce signals which are approximately proportional to the deviation, but the signals produced by *small* deviations are considerably less than proportional to the deviation. In this way the pots provide high aileron sensitivity to directional deviations without producing over-control.

(4) **THE DASHPOT** — The Dashpot proper, shown in Fig. 62, consists essentially of a housing, a stationary sleeve, an adjusting cylinder and a piston or plunger so constructed that it can by-pass oil in either direction whenever the force upon the plunger exceeds the tension of the valve openings.

Under conditions of gradual action, the plunger will move up and down in the adjusting cylinder slowly, and oil will flow from below the plunger around the lower end of the adjusting cylinder, up the outside and then through the discharging ports to the space above the plunger. The opposite flow takes place whenever the plunger is raised.

The amount of the restraining force provided by the Dashpot can be varied by turning the adjusting cylinder either in or out of its stationary sleeve. Note that when the cylinder is turned in, the restraining

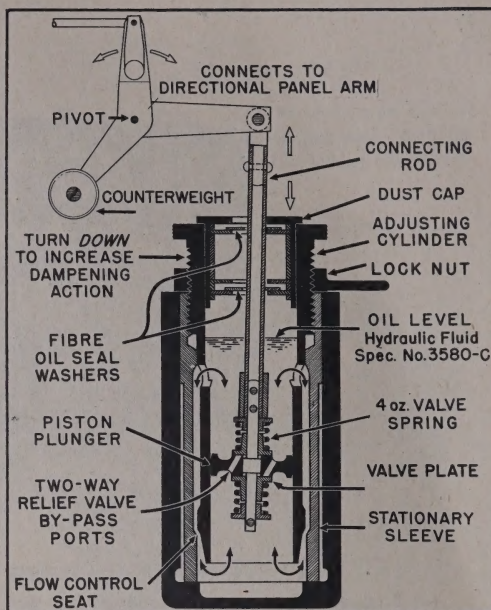


Fig. 62—Cross-section of the Dash Pot

force is increased, since the annular opening at the flow control seat is reduced. The position of the adjusting cylinder can be manually locked or secured in place by turning the lock-nut with its attached lever.

The piston is precision fitted to its cylinder and is therefore not interchangeable with other units.

A double-action relief valve built into the piston or plunger permits passage of oil to either side of the plunger whenever pressure builds up beyond the limits of its setting. This setting is 4 ounces and should not be disturbed. The valve is intended to prevent damage to the linkage connecting the piston to the rudder potentiometer wiper. Escape of oil around the piston or plunger rod is prevented by a tightly fitted gland in the top of the cylinder. This gland contains a series of flat, thin washers which wipe the oil from the piston rod.

The counterweight is provided on the bell crank in order to offset the action of gravity on the piston. The linkage is interconnected with a series of straight pins closely fitted. Lost motion and friction is so critical in this assembly that these pins are not considered interchangeable. Alignment of the bearings holding the shaft connecting the bell crank and counterweight is also so critical that they should not

be disturbed unless the counterweight fails to function properly.

(5) WIRING OF THE DIRECTIONAL PANEL

—Electrical connections to the Directional Panel are made through two A-N connector receptacles mounted on the bottom of the housing. The three-prong connector on the left is connected to the rudder pickup pot, and the seven-prong connector is connected to the banking pots and the E.C.O. switch, as shown in Fig. 63.

(6) SPECIFICATIONS

(a) RESISTANCES (Refer to figure 142A for table of resistance values.)

Rudder Pot	R9
Dual Banking Pots, each (Type G1005B)	R10
Banking Pot series resistors, each	R11 and R12

(b) TENSIONS

Rudder Pot Wiper	6-8 grams
Banking Pot Wipers	8-12 grams
Center-tap Contacts	25+ grams
Centering Springs	7-9 grams

(c) CLEARANCES

Rudder pot-wiper rocker arm to centering spring	.001 inch
Rudder pot-wiper rocker arm to either stop from center	$\frac{1}{32}$ inch
Upper switch blade to cam bracket	.020 inch +.000 -.015
Movement of slide either direc- tion to open switch	$\frac{1}{8}$ inch
Switch contact gap	.030" $\pm$.015"

(d) WEIGHT

Including Dashpot filled with oil	3 lbs. 4 ozs.
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(7) EARLY MODEL DIRECTIONAL PANEL—

The first Directional Panels (Type G1005A) contained only one Banking Pot, provided with a dead-spot which would prevent aileron action until the plane had deviated more than 2° either side of the straight-course position, (Fig. 64). All minor course corrections were made entirely with the rudder.

The coiled centering spring shown was replaced by the two leaf springs used in the new model.

Other than these two changes, the construction of both the early and later models of the Directional Panels is essentially the same.

The primary purpose for making the changes in the Directional Panel was to provide greater directional stability for improved bombing accuracy.

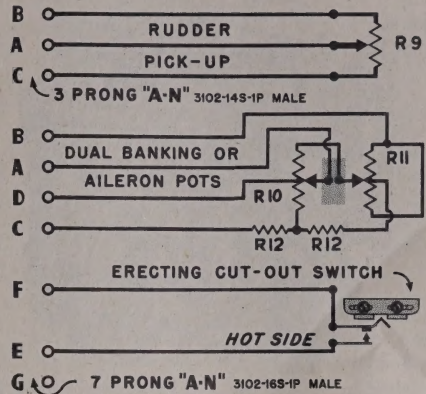


Fig. 63—Schematic Wiring Diagram of the Directional Panel

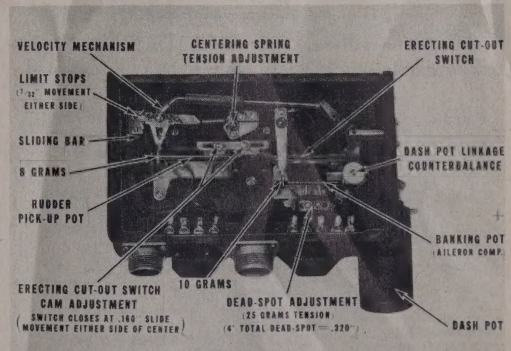


Fig. 64—Early Type G1005A Directional Panel with single Banking Pot

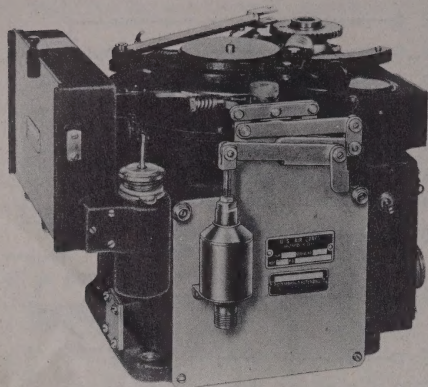


Fig. 65—Directional Arm Lock mounted on the Directional Stabilizer

d. DIRECTIONAL ARM LOCK

(1) FUNCTION

(a) The Directional Arm Lock is an electro-magnetic locking device mounted on the side of the Directional Stabilizer, as in Fig. 65.

(b) When a turn is made from the Turn Control, the Directional Arm Lock closes its *powerful clamping jaws* over the extension of the directional arm to hold the Autopilot clutch and Directional Panel drive-arm in fixed position relative to the Stabilizer case and the Directional Panel. This prevents the horizontal gyro in the Stabilizer from moving the Directional Panel mechanism during the turn, as any such movement would produce a corrective signal which would balance out or cancel the Turn Control signal and prevent the airplane from turning.

(2) DETAILS OF CONSTRUCTION

(a) The individual parts of the Directional Arm Lock assembly are shown in Fig. 66. Note that slotted

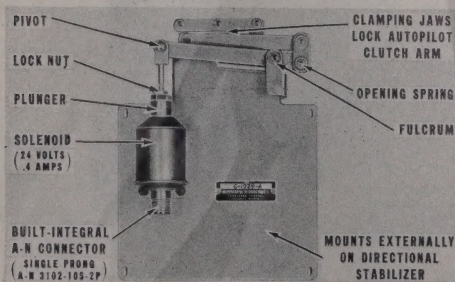


Fig. 66—Construction Details of the Directional Arm Lock

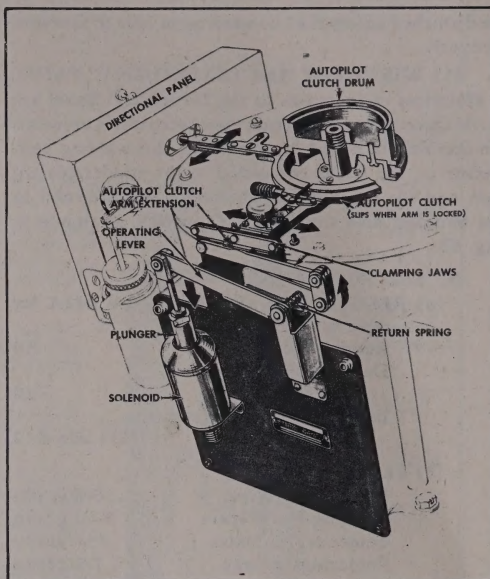


Fig. 67—Relation of the Directional Arm Lock to the Autopilot Clutch and Directional Panel

holes in the corners of the mounting plate permit adjustment of the complete assembly up or down to align the clamping jaws with the Autopilot clutch arm extension.

(b) Note also that the clamping force of the solenoid can be regulated by adjusting the length of the plunger connecting rod.

(c) When the Turn Control is moved from its center position, its integral switch completes a D.C. circuit through the Directional Arm Lock solenoid.

(d) The energized solenoid pulls the plunger down against the force of the spring, as in Fig. 67, forcing the lower clamping jaw upward.

(e) This locks the Autopilot clutch arm projection firmly in place between the jaws causing the Autopilot clutch to slip around its drum as the airplane turns.

(f) When the turn is completed, the Turn Control switch is opened, the solenoid is de-energized, the spring raises the operating lever to open the clamping jaws, and the Autopilot clutch again controls the Directional Panel.

(g) When the Directional Arm Lock is open, the bombardier can disengage the Autopilot clutch and make 18° banks by moving the clutch arm in either direction until it hits the stops on the top of the Stabilizer housing.

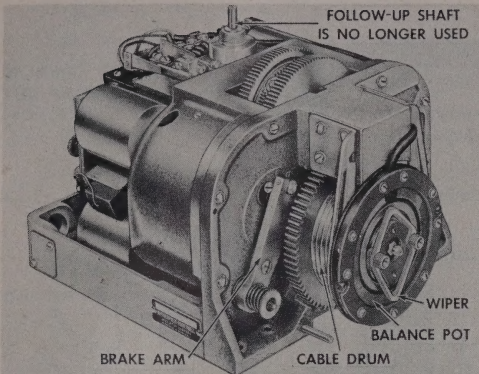


Fig. 73—Servo Unit, front view with covers removed

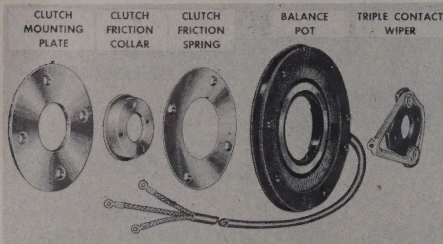


Fig. 74—Balance Pot assembly, exploded view

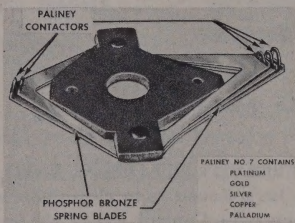


Fig. 75—Balance Pot Wiper

3. The balance pot shown in Fig. 72 and illustrated in Figs. 73 and 74 controls the amount of cable drum rotation resulting from a given deviation of the airplane.

4. The balance pot resistance element (R13) consists of nichrome wire wound around a flat bakelite ring, which, in turn, is clamped against a flat bakelite block. Mounted on this same block is a flat metal collector ring which eliminates the necessity of having a flexible lead wire to the wiper blade (Fig. 74).

5. The pot wiper is made of five V-shaped phosphor-bronze spring blades. The tip of each blade

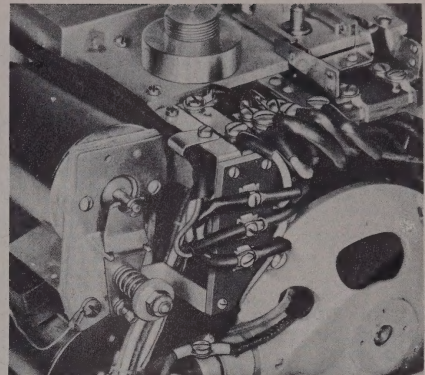


Fig. 76—Servo Unit with Vertical Terminal Block

is bent at right angles to the blade and is welded to a "Paliney" contact point. Two blades (shorter than the others) are fastened to one side of a bakelite block in such a way that their contact points ride on the collector ring. The three longer blades are mounted to the bakelite block at the same point, but extend in the opposite direction to contact the flat pot winding. This construction, which provides a triple contact with the pot, is clearly shown in Fig. 75.

6. The contact points of the wiper blades are set at a slight angle so they will produce a wiping, self-cleaning action as they traverse the nichrome wire winding. The complete wiper assembly is fastened to the cable drum by means of a friction clutch assembly, shown in Fig. 74, which facilitates centering the wiper at the electrical center of the pot when installing the Servo Unit.

7. Electrical connections to the balance pot and wiper are made at a terminal block at the rear of the unit. Figure 76 shows the type of block in current production, whereas Figure 68 illustrates an earlier type in common use.

8. Figure 77 illustrates the new type of balance

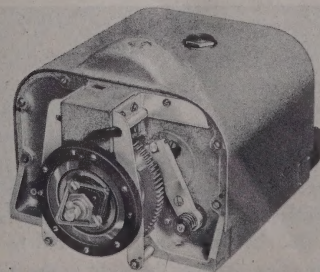


Fig. 77—Servo Unit Showing Long Pot Brackets

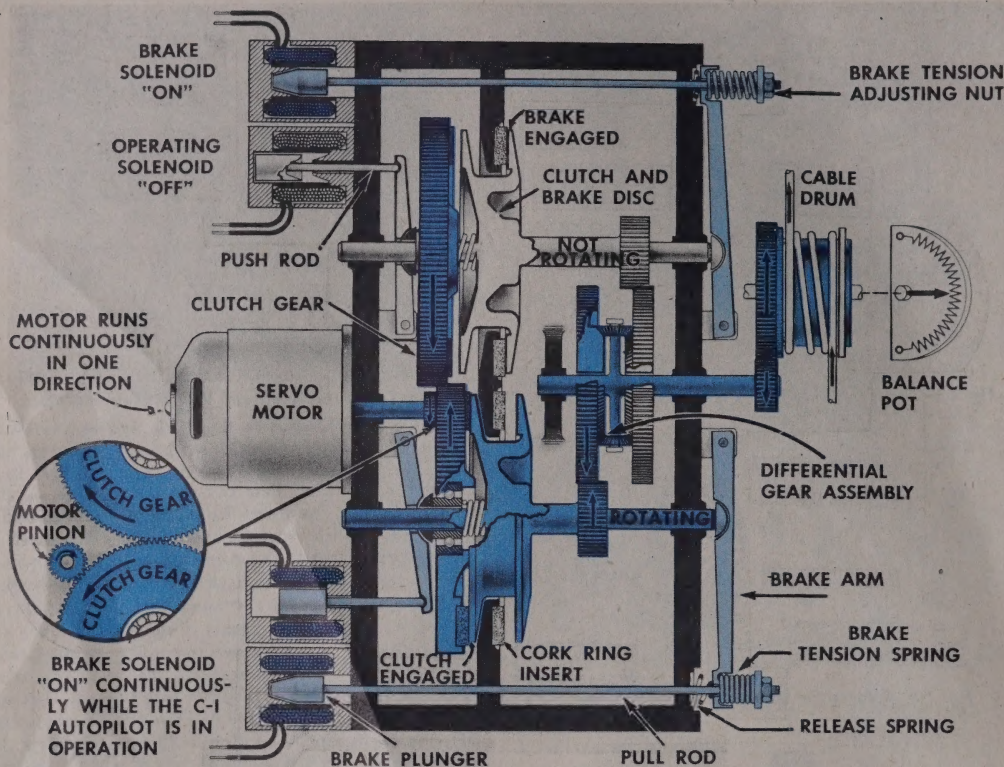


Fig. 78—Schematic Drawing (top view) of Servo Unit showing parts in operation

pot brackets. (Compare with earlier type shown in Figure 73.) The new bracket provides greater rigidity because its lower end is supported by a stud anchored in the Servo Unit frame.

(3) FUNCTION OF SERVO UNIT PARTS—The operation of the Servo Unit can be best understood by carefully studying the accompanying illustrations. Fig. 78 is a schematic drawing (top view) of the entire unit showing the relationship of its various parts at a time when the unit is actually driving the airplane control surfaces. Note that the Servo motor, which supplies the power, is at the left of the illustration, and that its power is transmitted by the gear train to the cable drum at the right of the illustration. The direction of cable drum rotation is determined by which of the two operating solenoids is energized.

(a) SERVO UNIT DISENGAGED—As soon as the Autopilot is turned on by closing the *master switch* on the Autopilot Control Panel, the motors in all three Servo Units begin to run and continue running as long as the Autopilot is in use. Each motor drives two clutch gears in opposite directions, as shown in the inset circle, Fig. 78. These two clutch gears rotate freely on their operating shafts and no motion is transmitted to the clutch-and-brake discs which are in their neutral positions, as shown in Fig. 79. In this situation the clutch release spring, between clutch gear and clutch-and-brake disc, is holding the clutch gear away from the clutch disc, and the brake disc away from the cork surface on the brake ring. The pilot is easily able to operate the control surfaces manually because both clutch-and-brake discs are free to rotate in response to any pull on the control cables.

(3) WIRING OF THE TURN CONTROL

(a) The pot, cam switch, trimmers and Control Transfer which go to make up the complete Turn Control system in the ACP are connected as shown in Fig. 85. Note that the ACP and Junction Box terminals are labeled.

(b) Fig. 86 is an internal wiring diagram of the Remote Turn Control.

(4) THE REMOTE TURN CONTROL

(a) The Remote Turn Control (Fig. 87) is a separate unit consisting of a knob-controlled pot and

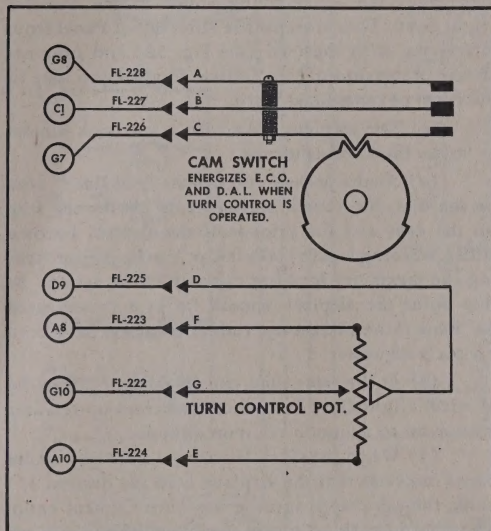


Fig. 86—Schematic Wiring Diagram of the Remote Turn Control

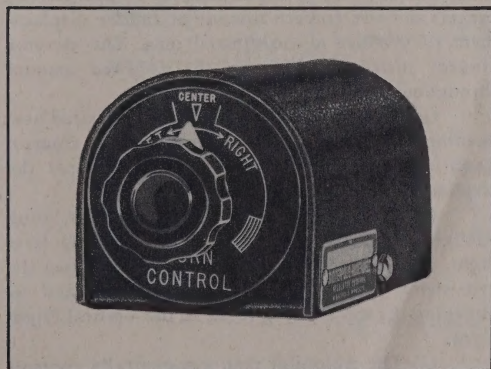


Fig. 87—Remote Turn Control

cam switch similar in construction to the Pilot's Turn Control in the ACP.

(b) The Remote Turn Control is mounted in the bombardier's or navigator's compartment. It enables the bombardier or navigator to take over directional control of the airplane when this is desirable.

(5) THE EARLY TYPE TURN CONTROL

(a) The separate Turn Control unit (Type G1027) employed in earlier Autopilot installations is illustrated in Fig. 88.

(b) This unit is sometimes called the "Twin-Pot" Turn Control because it contains two separate pots, one of which is connected in the aileron bridge circuit, the other in the rudder bridge circuit. Both pots are operated in unison by a single knob which also operates a cam switch similar to that described in paragraph (2) above.

(c) Coordination of aileron and rudder movement to produce properly banked turns is accomplished by the rudder and aileron T.C. trimmers that are mounted on the side of the unit. These trimmers are screwdriver-operated rheostats connected in series with one end of their respective control pots.

(d) Fig. 89 shows the internal construction of the separate Turn Control unit. Fig. 90 is an internal wiring diagram showing the interconnections between parts of the Turn Control and the A-N connector prongs.

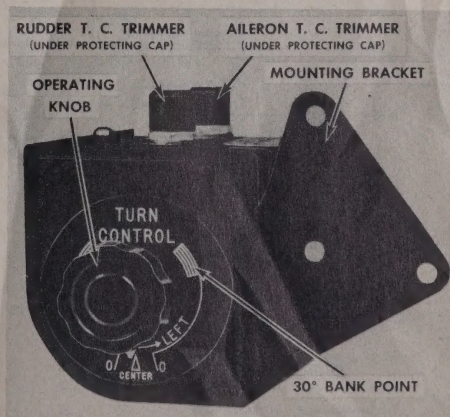


Fig. 88—Early Type G1027 Turn Control

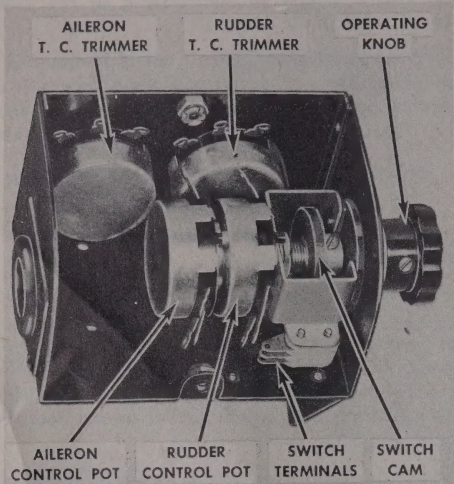


Fig. 89—Internal View of the G1027 Turn Control

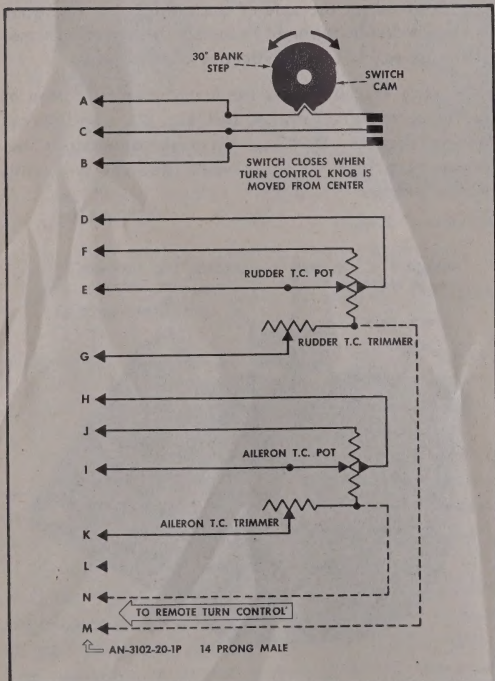


Fig. 90—Schematic Wiring Diagram of the G1027 Turn Control

(6) THE EFFECT OF THE TURN CONTROL ON OTHER AUTOPILOT UNITS—The best way to understand the relation of the Turn Control to other units in the system is to consider, in step-by-step sequence, what happens to the C-1 Autopilot and to the airplane when the Turn Control is operated.

(a) The pilot, desiring to bank the airplane 35° to the left in making a turn, rotates the Turn Control knob slowly to the left.

(b) Even before the pointer reaches the zero mark on the left side of the scale, the cam switch locks the Directional Panel slide in its center position and disengages the top erecting roller in the Vertical Flight Gyro. This prevents the Directional Panel from interfering with the turn (see Fig. 58) and prevents erratic precession of the Vertical Flight Gyro, due to the effect of centrifugal force.

(c) The airplane rolls into a left bank almost as fast as the knob is turned.

(d) As the pointer reaches the "red-lined" area on the dial, the switch spring blade climbs the step on the cam and the pilot feels the control become stiffer, warning him to "take it easy" for he is approaching the maximum banking capacity of the system. At this point the airplane should be in a coordinated 30° bank if the aileron and rudder trimmers have been properly adjusted.

(e) At the same time, the up-elevator pot in the Vertical Flight Gyro introduces sufficient up-elevator movement to maintain constant altitude.

(f) When the Gyro Horizon on the instrument panel indicates that the airplane is in the desired 35° bank, the pilot stops turning the Turn Control knob. The aileron pick-up pot in the Vertical Flight Gyro streamlines the ailerons, holding the airplane in the desired bank. The skid pot (rudder compensation) cancels out the correct amount of rudder displacement to produce a coordinated turn. The elevator control surface remains up the required amount throughout the turn.

(g) As the airplane approaches its desired new heading, the pilot starts turning the Turn Control knob slowly back toward zero which causes the airplane to start leveling off.

(h) The pilot stops the pointer at zero long enough for the airplane to assume perfectly level flight, then he centers the Turn Control to open the cam switch unlocking the Directional Arm and re-engaging the top erecting roller in the Vertical Flight Gyro.

(i) The Autopilot then automatically controls the airplane in straight-and-level flight.

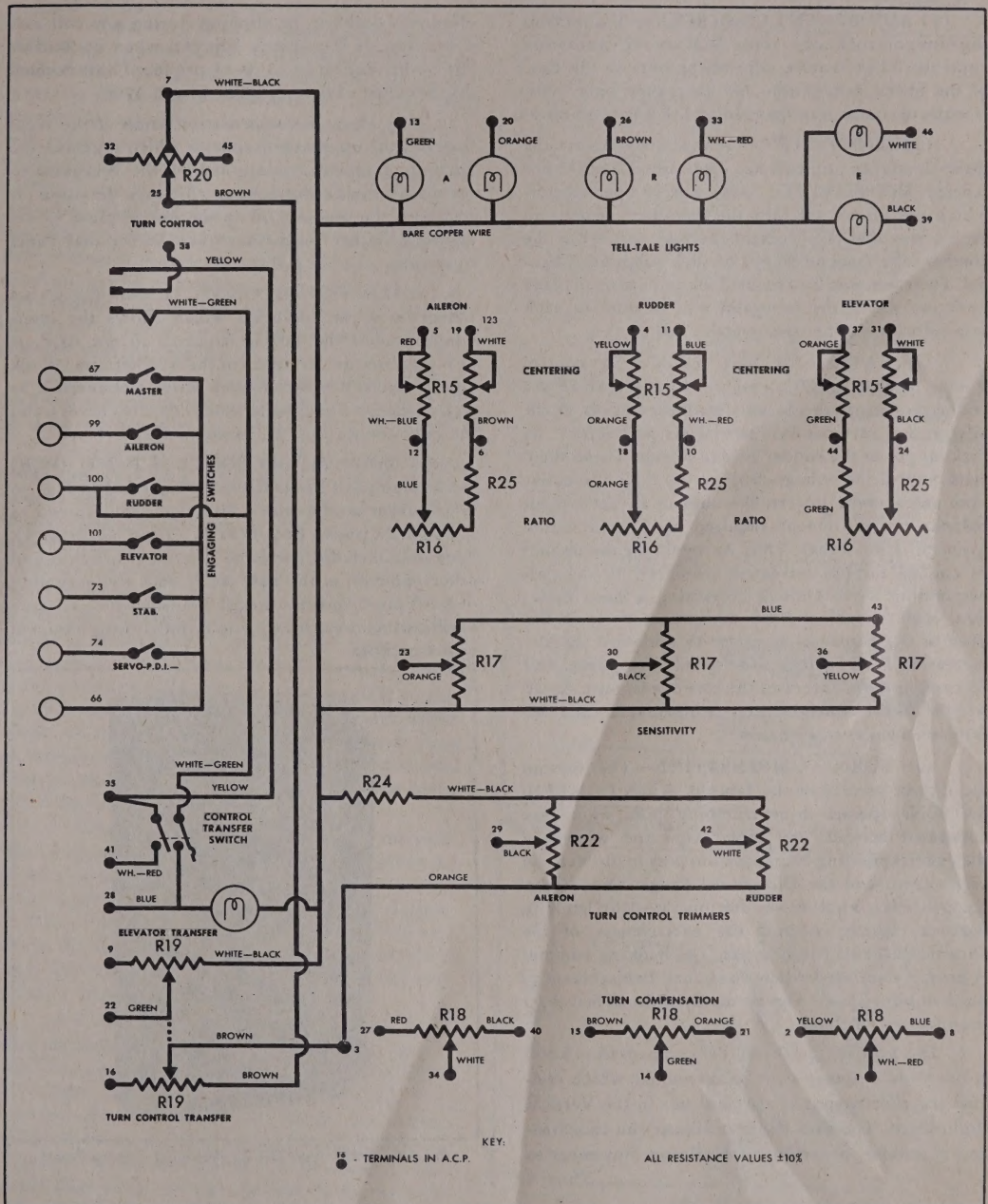


Fig. 95—Schematic Wiring Diagram of Autopilot Control Panel (without Formation Stick)

(5) **ADJUSTMENT CONTROLS**—The remaining nine control knobs on the ACP are the calibration controls. They require adjustment only at the time of the initial installation and thereafter only occasionally to compensate for changes in flying conditions.

(a) **SENSITIVITY**—Immediately below the three Centering controls are three adjustment knobs labeled **SENSITIVITY**. These knobs operate pots which are connected into the Amplifier circuits in such a way that they control the bias applied to the control tube (second stage) of each Amplifier Channel. Their function is to control the amount of airplane deviation which the Autopilot will tolerate in each axis before applying its corrective action.

(b) **RATIO**—The next set of three control knobs, labeled **RATIO**, operate rheostats which are connected across the Servo Unit balance pots in the aileron and elevator bridge circuits and across the pick-up pot in the rudder bridge circuit. These rheostats control the voltage-drop across their respective pots and thereby govern the amount of Servo Unit balance pot movement required to balance out a given deviation signal. Thus, by regulating the amount of control surface movement produced by the corresponding Servo Unit in correcting a flight deviation, each individual *Ratio* adjustment controls the speed of the airplane's response to deviation signals. Increasing *Ratio* increases the speed of response, and decreasing *Ratio* decreases the rate of response. Once set, the Ratio controls need readjustment only for extreme changes in air speed.

(c) **TURN COMPENSATION**—The bottom set of three control knobs, labeled **TURN COMPENSATION**, operate three trimming pots which are connected between the center taps and wipers of their corresponding compensation pots in the Vertical Flight Gyro and the Directional Panel. The aileron compensation knob at the left operates the banking trimmer, which controls the effectiveness of the Directional Panel banking pot. The banking trimmer is properly adjusted when maximum displacement of the Autopilot Clutch Arm on the Directional Stabilizer produces an 18° bank.

In a similar way, the rudder compensation knob in the middle operates the skid trimmer which controls the effectiveness of the skid pot in the Vertical Flight Gyro. The skid trimmer adjusts the coordination of rudder movement with aileron movement to

eliminate skidding or slipping during any roll axis correction. It is properly adjusted when no skid or slip occurs during an 18° bank produced by maximum displacement of the Autopilot Clutch Arm.

The elevator compensation knob at the right operates the up-elevator trimmer which regulates the amount of up-elevator applied by the Autopilot to maintain altitude during any roll axis deviation. It regulates the amount of up-elevator applied in response to either Turn Control or Directional Panel operation.

(6) **ELECTRICAL CONNECTIONS**—Fig. 95 is a schematic wiring diagram which shows the interconnection of the various controls in the ACP. It also indicates the terminals of the ACP terminal block (black circles) to which each wire is connected, as well as the junction box terminals (white circles), and the inter-connecting "FL" wire numbers.

(7) **EARLY MODEL CONTROL PANEL (PCB)**—The Autopilot Control Panel illustrated in Fig. 96 is an earlier model which was commonly known as the Pilot's Control Box or PCB. (Type No. G1023). This unit includes the same engaging switches and other controls as the new ACP, with the exception of the Turn Control, Control Transfer and Tell-Tale Lights, which were separate units individually mounted in the cockpit.



Fig. 96—Early Type G1023 Autopilot Control Panel

Operation of this voltage-divider regulates the voltage applied to the grid resistor between the limits A and C in Fig. 124. When the sensitivity voltage is set at A, the sensitivity of the system is said to be high because the negative peaks of even very small signals will cause the plate current to fluctuate and transmit a signal to the discriminator tube. When the sensitivity voltage is set at C, the sensitivity of that particular Amplifier channel is said to be low, for it is apparent that the negative peaks of the signal must be sufficiently strong to reduce the applied voltage from C to A before they have any effect on the plate current (Fig. 125). Normal setting of the sensitivity voltage is in the vicinity of point B, except when extreme accuracy of flight control is required.

No matter where the sensitivity voltage is set, the positive portions of the signal have no appreciable effect on the plate current.

3. **FEEDBACK**—Signals which are just barely strong enough to offset the positive sensitivity voltage result in weak plate voltage fluctuations. These weak signals, when applied to the discriminator tube would result in hesitant, chattering operation of the relays or possibly no relay operation at all. Therefore, the circuit provides for the application of a negative **FEEDBACK** voltage which reduces the sensitivity voltage, as shown in Fig. 126. This voltage is a pulsating, negative D.C. voltage which is picked up from the resistor (R36) illustrated toward the right in Fig. 123. Note that whenever current flows through either section of the discriminator tube, a voltage drop appears across this resistor, and the negative potential of the top end of the resistor (R36) is fed back to the grid of the control stage.

When an A.C. signal is applied to the grid of the control tube with the sensitivity set at point A, the effect of the feed-back voltage is to increase the sensitivity of the tube by shifting the bias point slightly to the left of point A, as shown in Fig. 126. This will increase the amplifying effect of the tube to produce strong, firm closing of the proper relay in the discriminator plate circuit.

4. **THROTTLING** — The instant the relay closes, the center relay contacts close a circuit which applies a strong positive voltage called the **THROTTLE** voltage to the grid of the control tube. The throttle voltage is picked up from the corresponding throttle adjustment rheostat on the front of the Amplifier chassis. The throttle circuit may be traced on the diagram (Fig. 123) from the top filter choke, through the throttle rheostat, through the relay contacts to the grid of the control tube.

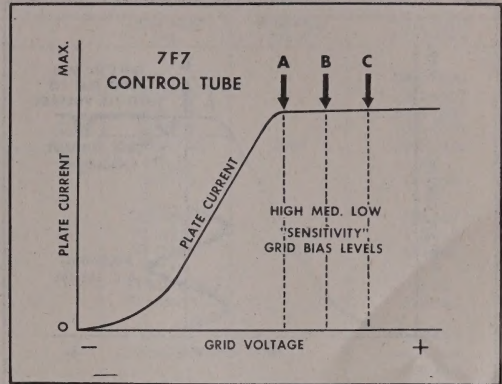


Fig. 124—Characteristic Curve of the Control Tube

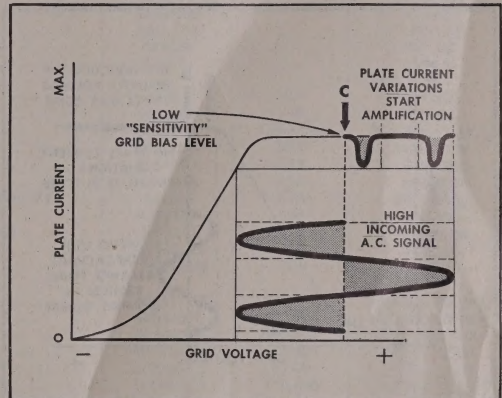


Fig. 125—Effect of Low Sensitivity on Control Tube Operation

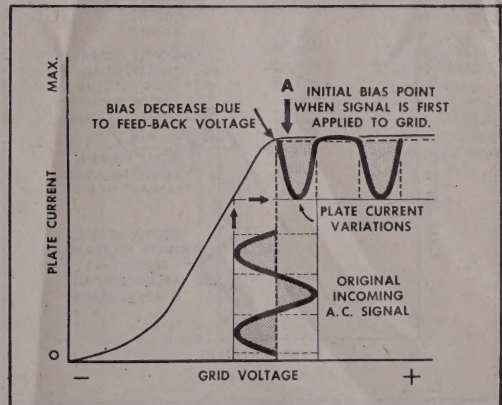


Fig. 126—Effect of Feed-back on Control Tube Output

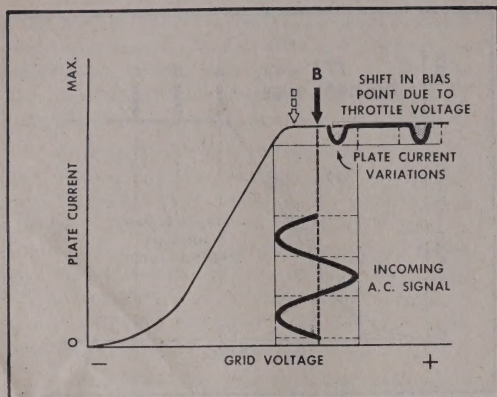


Fig. 127—Effect of Throttle Voltage on a strong Signal

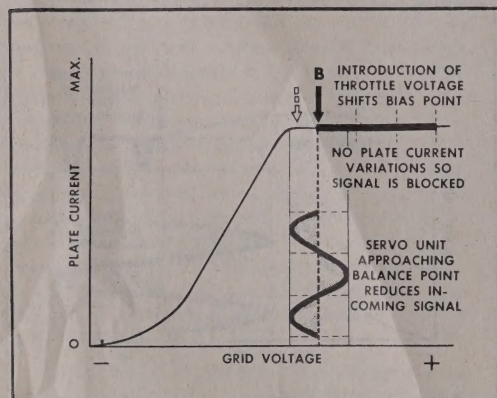


Fig. 128—Effect of Throttle Voltage on a weak Signal

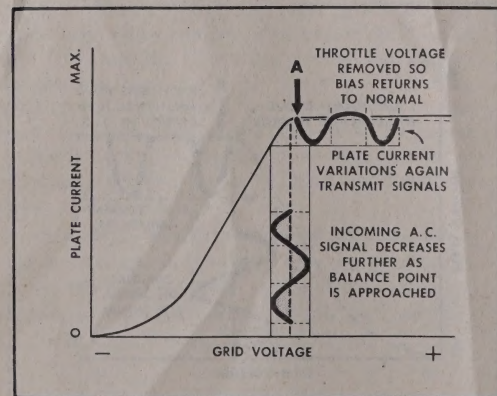


Fig. 129—Signal diminishes as Servo reaches Balance Point

The effect of the throttle voltage is to move the bias point of the tube toward the right to position B in Fig. 127. Comparing Figs. 126 and 127, note how this positive shift of the bias point decreases the size of the plate current variations resulting from the same input signal. The tube continues to operate with the bias point at B as long as the signal is strong enough to cause plate current variations. However, as the Servo Unit starts to balance the bridge circuit, the incoming A.C. signal gradually diminished until the condition shown in Fig. 128 is reached. At this point the signal is not sufficient to overcome the strong positive bias and plate current fluctuations cease. When this happens the relay opens, breaking the throttle circuit and removing the throttle voltage, with the result that the bias point is returned to position A, as in Fig. 129.

In the meantime, the Servo Unit has rotated toward the balance point, reducing the A.C. signal. With the bias point at A, however, the signal is strong enough to close the relay again. This time the relay closes only for an instant, because as soon as it closes, the throttle voltage is again applied to the tube to block the signal.

Thus, the relay is made to open and close repeatedly, causing intermittent Servo Unit operation as the balance point is approached.

The frequency with which the relay operates is determined by the time-delay circuit which is a combination of a condenser and resistor shunted across a portion of the grid circuit together with the relay holding condenser. Each time the relay closes, this condenser stores up energy which maintains the throttle voltage on the grid of the tube, preventing the signal from closing the relay again for about 15 cycles after the relay opens.

The resulting intermittent operation of the Servo Unit is called *pecking action*. Its purpose is to cause the Servo Unit to move the airplane's control surfaces slowly into position as the Servo Unit balance pot approaches its balance point. This prevents "over-control" of the airplane.

The length of each "peck" is determined by the relay contact gaps, the relay spring tension, the Servo Units operating solenoid spring tension, and other factors.

The size or amplitude of the smallest signal which will produce continuous operation of the Servo Unit is determined by the setting of its corresponding throttle adjustment on the front of the Amplifier chassis, aileron, rudder or elevator.

(NOTE: These values are given for checking purposes only. Replacement parts should be ordered from the parts catalog, AN 11-60AA-3.)

DESCRIPTION	M-H PART NO.	NOMINAL VALUE	PERMISSIBLE TOLERANCE
VERTICAL FLIGHT GYRO:			
R1 Elevator potentiometer	405381A		1000-1600
R2 Aileron potentiometer	405472B		1000-1600
R3 Skid potentiometer	405472B		1000-1600
R4 Up-elevator potentiometer	405472B		1000-1600
R5 Up-elevator circuit resistor	21994CAC	2000	1600-2400
F1 Field coil	425318		2-3
F2 Erecting cut-out magnet coil	425771A		110-150
STABILIZER:			
R6 PDI potentiometer	ST425949A		290-365
R7 Clutch limiting resistors, each	ST425590	190	170-210
R8 Clutch magnet damping resistor, each	ST426294	500	440-460
F3 Gyro field coils, each	425511		7-9
F4 Torque motor field coils, each	ST425931A		43-62
F5 Clutch magnet coils, each	ST425935A		315-385
DIRECTIONAL PANEL:			
R9 Rudder potentiometer	406196		330-440
R10 Banking potentiometer, upper	406402-03		300-400
R11 Banking potentiometer, lower			300-400
R12 Banking potentiometer, fixed resistor (each winding)	406171	340	320-360
SERVO UNIT:			
R13 Balancing potentiometer (180°)	407205A		950-1300
R14 Balancing potentiometer (90°)	407205B		475-650
F6 Motor field, both in series	426117A		100-120
F7 Brake solenoid, each	425089		200-260
F8 Clutch solenoid, each	425079		45-65
AUTOPILOT CONTROL PANEL:			
R15 Centering potentiometers, each	21329	200-	175-225
R16 Ratio potentiometers, each	405320F	500	450-550
R17 Sensitivity potentiometers, each	405315G	1,000,000	800,000-1,200,000
R18 Compensation trimmers	405320G	2000	1800-2200
R19 Control transfer potentiometers, each	406494A	2000	1800-2200
R20 Turn control potentiometer (in ACP)	406904B	890	800-1000
R21 Turn control potentiometers, each (in Type G1027 turn control)	405604	1780	1600-2000
R22 Turn control trimmers, each (in ACP)	405320F	500	450-550
R23 Turn control trimmers, each (in Type G1027 turn control)	405320J	5000	4500-5500
R24 Protective turn control trimmer resistors	21994CAB	200	180-220
R25 Protective ratio resistors, each	21995BAB	100	90-110
AMPLIFIER:			
R26 Throttle control potentiometer, aileron	405315H	500,000	400,000-600,000
R27 Throttle control potentiometer, rudder	405315H	500,000	400,000-600,000
R28 Throttle control potentiometer, elevator	405315H	500,000	400,000-600,000
R29 Bias control potentiometer	405320JA	5,000	4,500-5,500
R30 Bias control-to-ground	21995JAC	8,000	7,200-8,800
R31 Protective throttle resistors, each	21450BFE	150,000	120,000-180,000
R32 Filament resistors, each	21992FEA	15	13.5-16.5
R33 Grid resistors, each	21450BAD	10,000	8,000-12,000
R34 Protective sensitivity resistor	21450CFE	250,000	200,000-300,000
R35 R.C. time delay resistor, each	21450BAE	100,000	80,000-120,000
R36 Feed back voltage resistor, each	21995FAB	500	400-600
R37 First stage 7F7 plate resistor, each	21450CFE	250,000	200,000-300,000
R38 Second stage 7F7 plate resistor, each	21450CFE	250,000	200,000-300,000
R39 7F7 plate resistor—common, each	21450FAD	50,000	40,000-60,000
R40 Second stage 7F7 grid-to-condenser resistor, each	21450FAE	500,000	400,000-600,000
R41 Condenser-to-throttle contact resistor, each	21450FAE	500,000	400,000-600,000
R42 Sensitivity-to-throttle contact resistor, each	21450FAE	500,000	400,000-600,000
R43 Discriminator bias-to-grid resistor, each	21450FAE	500,000	400,000-600,000
F9 Relay magnet coil	405911A		5,000-6,800
DIRECTIONAL ARM LOCK:			
F10 Locking solenoid			55-75
INVERTER:			
R44 Series field—d-c brush-to-brush			
R45 Series field—d-c brush-to-brush			
R44 Shunt field—d-c brush-to-brush (Eicor)			
R45 Shunt field—d-c brush-to-brush (Westinghouse)			
JUNCTION-BOX RATIO RESISTORS:			
R46	407220A	300	270-330
R47	407220B	1000	900-1100
R48	407220C	500	450-550
R49	407220D	600	540-660
R50	407220E	360	320-400

Figure 142A — Table of C-1 Autopilot Resistances

Section III

OPERATION



1. PRECAUTIONS PRECEDING TAKE-OFF

a. **GROUND CHECK REQUIREMENTS**—Make sure the C-1 Autopilot system has been completely ground-checked during the preceding 100 hours of Autopilot operation. The procedure for this ground check is outlined in detail in Section 5, Paragraph 2 a. After each time any inspection or repair work is done involving the removal of covers or the replacement of units it is necessary to perform the brief preflight check, outlined below.

b. **COLD WEATHER PRECAUTIONS**—It is important that special precautions be taken in operating the Autopilot during cold weather. If the temperature of the equipment is between -12° C. (10° F.) and 0° C. (32° F.), it is advisable to run the Vertical Flight Gyro and the Directional Stabilizer while the engines are being warmed up, in order to warm up the lubricants and insure quick erection of the gyros when the Autopilot is engaged. Be sure to turn off all Autopilot switches before taking off. If temperatures are below -12° C. (10° F.), special heating equipment should be used in warming up the units. Refer to paragraph 6 for complete cold-weather instructions.

2. BRIEF PREFLIGHT CHECK

a. The following preflight check must be performed by the crew chief during the engine warm-up period at least once each day airplane is used.

(1) Make sure Turn Control (or controls) is centered and bombsight clutch on Stabilizer is disengaged (lever toward you) as in Fig. 192.

- (2) Turn on Autopilot master switch.
- (3) Set all adjusting knobs on ACP to "pointers up" position. Make sure pointers are not loose.
- (4) Disengage Autopilot clutch (Fig. 193) and center PDI on top of the Stabilizer. Re-engage Autopilot clutch.
- (5) Turn on Servo PDI switch on ACP.
- (6) Operate the airplane controls manually to move the control surfaces through their extreme ranges of movement several times. This will slide the Servo

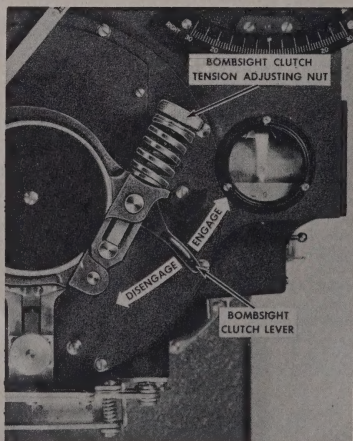


Fig. 143—Engaging Lever on Bombsight Clutch

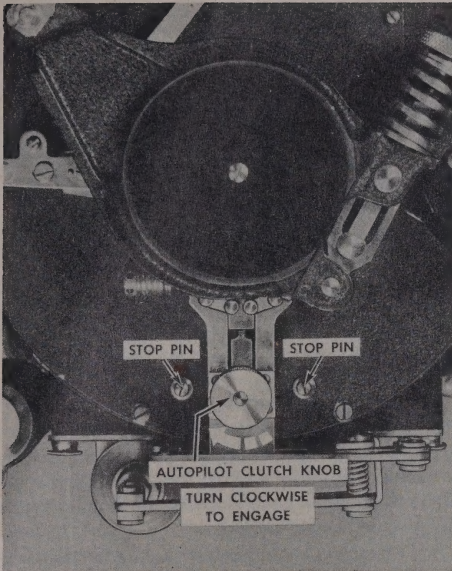


Fig. 144—Engaging Knob on Autopilot Clutch

Unit balance pot wipers over their respective pots and should clean off any dust or dirt that is on the pots.

(7) Observe action of tell-tale lights as controls are moved. When controls are near streamlined position, lights will flicker as the Servo Unit balance pot wiper crosses the electrical center of the pot. When controls are at the extreme ends of their ranges, the lights may go out as the pot wiper runs off the winding. At all intermediate positions, one light or the other will remain on steadily. If the lights flicker at intermediate control positions, the corresponding balance pot requires cleaning.

(8) Turn on aileron engaging switch. One aileron light will come on, then flicker, and go out as the ailerons move to streamlined position.

(9) Turn on rudder and elevator switches in the same manner.

(10) Turn aileron centering knob clockwise. This should cause control wheel to turn to the right. Counterclockwise rotation of the aileron centering knob will cause the control wheel to turn to the left.

(11) Rotate rudder centering knob clockwise. Right rudder pedal should move forward. Then rotate knob counterclockwise; left pedal should move forward.

(12) Turn elevator centering knob clockwise. Control column should move back. Then turn knob clockwise; control column should move forward.

(13) Turn Autopilot clutch knob on Stabilizer counterclockwise and move Autopilot clutch arm to extreme left. Be sure it moves freely without binding. Observe that aileron wheel turns to the right and that right rudder pedal moves forward.

(14) Move Autopilot clutch arm to the extreme right and observe that the wheel turns to the left and that the left rudder pedal moves forward.

(15) Return Autopilot clutch arm to center. Check by observing the PDI wiper through the window on top of the Stabilizer. Engage Autopilot clutch by turning knob clockwise.

(16) Rotate the Turn Control knob for a 30 degree right turn and observe that wheel turns to the right and that the right rudder pedal moves forward.

(17) Rotate the Turn Control knob for a 30 degree left turn and observe that the wheel turns to the left and that the left rudder pedal moves forward.

(18) If a malfunction is detected in this procedure, it is necessary to refer to the complete ground check described in Section 5, par. 2 a.

(19) If all checks are okay, turn off master switch.

3. HOW TO ENGAGE THE C-1 AUTOPILOT

a. BEFORE TAKE-OFF

(1) Unless the knobs on the Autopilot Control Panel are known to be properly adjusted, turn them to "pointers-up" position.

(2) Center Turn Control (A), and make sure that control transfer knob (G) is at "pilot."

(3) Engage Autopilot clutch by turning knob clockwise (Fig. 193).

(4) Disengage bombsight clutch by pulling lever toward you (Fig. 192).

b. AFTER TAKEOFF

(1) Throw "ON" master and Stabilizer switches connected by bar (B).

(2) After ten minutes, throw on PDI Servo switch (F) on Autopilot Control Panel.

NOTE

On early model Autopilot Control Panels, PDI and Servo switches were separate.

(3) Turn on tell-tale lights or open shutter.

(4) After leveling off at cruising altitude, "get

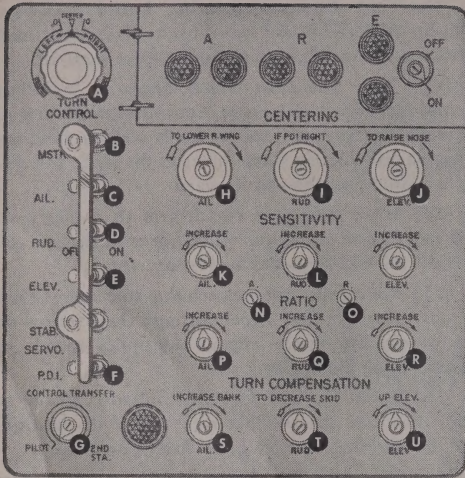


Fig. 145—Autopilot Control Panel, Reference Drawing

on the step”—that is, make sure airplane is *flying* at cruising speed, not *mushing* along. Then very carefully trim airplane for straight-and-level flight.

(5) After master switch has been on for ten minutes (to be sure gyros are erect) center PDI by either of the following methods:

(a) Bombardier, disengage Autopilot clutch and center PDI by moving Autopilot clutch arm to its center position. Then lock it in place by depressing the Directional Arm Lock. Hold PDI centered until pilot has completed engaging procedure; reengage Autopilot clutch and release Directional Arm Lock.

(b) *Alternate:* Pilot, center PDI by turning airplane in direction of PDI needle (Fig. 195). Then, with PDI centered, resume straight-and-level flight.

(6) With wings level, adjust aileron centering knob (H) until both aileron tell-tale lights are out. Immediately throw aileron switch (C) “ON.”

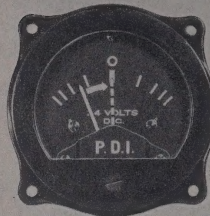
(7) With PDI on zero, adjust rudder centering knob (I) until both rudder tell-tale lights go out. Immediately throw rudder switch (D) “ON.”

(8) With airplane flying level, adjust elevator centering knob (J) until both elevator tell-tale lights go out. Immediately throw elevator Switch (E) “ON.”

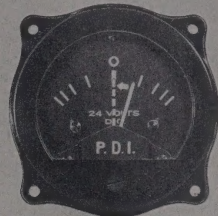
(9) Observe PDI, Artificial Horizon and Rate-of-Climb or Altimeter instruments, and then carefully retrim all centering knobs until ship is flying as straight and level as possible, with PDI on center.

(10) With Autopilot clutch engaged and bomb-sight clutch disengaged, all course corrections must

P.D.I. MUST BE CENTERED WHEN RUDDER SERVO IS ENGAGED
TO CENTER P.D.I. TURN AIRPLANE MANUALLY



WHEN P.D.I. IS LEFT
TURN AIRPLANE TO THE LEFT



WHEN P.D.I. IS RIGHT
TURN AIRPLANE TO THE RIGHT

Fig. 146—Centering PDI by Turning Airplane

be made only with Autopilot Turn Control. Always turn knobs with a slow, steady movement.

(11) After the C-1 Autopilot is in operation, the pilot should carefully analyze the action of the ship to determine which control surfaces may not be operating properly.

(12) Before attempting any further changes on the Autopilot Control Panel, the pilot should understand what is meant by *centering*, *sensitivity*, *ratio*, and *turn compensation*, and how these knobs adjust the action of the electronic Autopilot so that the plane will fly correctly.

4. FLIGHT ADJUSTMENTS

a. *GENERAL*—Control knobs are provided on the Autopilot Control Panel to permit precise adjustment of its operation for maximum efficiency under any flight or load-carrying condition. Once these adjustments have been set for a particular airplane, only slight readjustments will be required each time the Autopilot is used—unless, of course, flight or load conditions change considerably.

b. *CENTERING*—The centering controls (H, I, and J) on the ACP are comparable to the trim tabs of the airplane. They control the normal attitude of the airplane while the Autopilot is in operation. Adjustment of the centering knobs aligns the electrical center of the Servo Unit balance pot with the pot wiper when the control surfaces are in trim.

When flying under Autopilot control, use centering knobs in place of the mechanical trim tabs to compensate for *slight* changes in air speed, CG, or gross weight. When large changes of air speed, CG, or gross weight occur, it is necessary to disengage the Autopilot, retrim mechanically, and re-engage as in steps 5 through 9 of paragraph 3.

CAUTION

Never trim the controls manually with the mechanical trim tabs while the Autopilot is in operation. Use of the trim tabs will not change airplane's attitude because the Autopilot will counteract the effect of the trim tabs. Then when Autopilot is disengaged trim tabs will suddenly become effective and produce a violent reaction.

c. **SENSITIVITY**—The sensitivity knobs control the alertness of the Autopilot, which is comparable to a human pilot's reaction time. A pilot may apply a correction for even the slightest deviation (high sensitivity) or he may wait for a larger deviation before applying the correction (low sensitivity).

d. **RATIO**—The ratio knobs regulate the amount of control surface movement resulting from a given deviation of the airplane. Thus, with a high ratio setting, the Autopilot may apply too much control surface in correcting a given deviation, giving fast recovery, which may cause overcontrol and "ship hunt." On the other hand, if ratio is set too low, the Autopilot will apply too little control in correcting a deviation, producing smooth recovery which may be too slow for correct flight.

Ratio usually requires adjustment only with extreme changes in air speed. (After ratio knobs are adjusted, it may be necessary to recheck centering.)

e. **TURN COMPENSATION**—Immediately after engaging the system and making sure sensitivity and ratio are well adjusted, the pilot will check the turn Compensation adjustments as follows:

(1) Have bombardier disengage Autopilot clutch and move the clutch arm slowly to extreme right or extreme left (Fig. 196).

(2) Adjust aileron compensation control (S) to produce an 18 degree bank, as indicated by the Artificial Horizon.

(3) Adjust rudder compensation (T) to produce a perfectly coordinated turn, as indicated by the Ball-Bank Inclinator. Ball must be in exact center.

(4) Make final adjustments with both knobs (S and T) to obtain a perfectly coordinated turn with 18 degree bank.

(5) Adjust up-elevator trimmer (U) to apply sufficient up-elevator to maintain altitude during the turn. (This up-elevator trimmer may require readjustment with changes in load or airspeed.)

(6) Have bombardier re-engage Autopilot clutch at its extreme position, and allow the Stabilizer to recenter PDI.

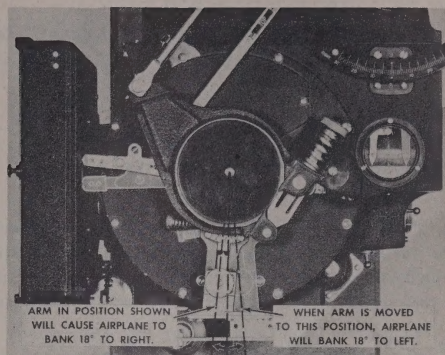


Fig. 147—Bombardier Can Turn Airplane by Moving Autopilot Clutch Arm

NOTE

Allowing the directional gyro in the Stabilizer to recenter PDI affords an opportunity to check aileron ratio. Bear in mind that after the Autopilot clutch is engaged, the airplane must turn $5\frac{1}{4}$ degrees to center PDI from the extreme position. If aileron ratio is too high, the wings will quickly level off before the airplane has turned the necessary $5\frac{1}{4}$ degrees. Then, with only rudder in effect, the airplane will skid and turn more slowly to center PDI. If aileron ratio is too low, the airplane will quickly turn the necessary $5\frac{1}{4}$ degrees to center PDI, but the wings will not level off fast enough and the airplane will continue to turn, causing the PDI to overshoot center. The result will be a fishtail action as the airplane straightens out.

f. **TURN CONTROL ADJUSTMENT**—The Turn Control (A) offers the pilot a convenient means of changing the airplane's heading while flying under Autopilot control. The Turn Control seldom requires readjustment unless there is reason to believe that a previous adjustment may have been changed. This adjustment is made only after the turn compensation adjustments outlined have been completed.

(1) Rotate Turn Control knob (A) slowly, either to right or to left, until pointer reaches the lined region of the dial or until you feel a distinct resistance to further rotation.

(2) At that setting, adjust the aileron trimmer (N) on the ACP (or on the side of the Turn Control box in earlier installations) to produce a 25 to 30 degree bank as indicated by the Artificial Horizon (preferably as near 30 degrees as possible).

(3) Adjust rudder trimmer (O) to produce a perfectly coordinated turn, as indicated by the Inclinator. Final adjustments are made with both trimmers.

(4) Slowly return pointer to zero and hold it there while airplane resumes level flight.

(5) When airplane has leveled off, recenter Turn Control pointer.

CAUTION

Pilot must never operate Turn Control without first making sure PDI is centered and bombardier is not making a turn with the Autopilot Clutch.

g. TURN CONTROL OPERATION—Whenever it is desired to turn the airplane to a new heading while flying on Autopilot control, the pilot can execute the turn by an easy manipulation of the Turn Control:

(1) Rotate Turn Control (A), Fig. 194, slowly in the direction of turn desired. As the pointer passes the zero mark, you will feel a "click" as the switch in the control closes, energizing the erecting cutout and Directional Arm Lock.

(2) Stop rotation of knob when Artificial Horizon indicates airplane has reached desired degree of bank.

NOTE

A warning stop causes the knob to turn with increased difficulty after the signal for a 30 degree bank has been applied. This is to warn the pilot to "take it easy" as he is approaching the maximum degree of bank obtainable (40 degrees). A steeper bank may cause the Vertical Flight Gyro roller spindle to strike against its stop on the gyro cover, resulting in precession.

(3) As the airplane approaches the desired new heading, slowly rotate control knob back to zero, timing this return so the pointer will reach zero when the desired heading is attained.

(4) Hold the pointer at zero until the airplane has leveled off on its new heading, then recenter the pointer to re-engage the erecting roller and release the Directional Arm Lock. (No signal is applied by Turn Control when pointer is at either zero mark.)

b. OPERATION OF THE CONTROL TRANSFER

—If the Autopilot system includes a second Turn Control at a remote station (as in the bombardier's or navigator's compartment), the ACP will be provided with a Control Transfer (G) in the lower left-hand corner. This control enables the pilot to transfer control of the airplane smoothly and gradually from the Turn Control in the ACP to the remote Turn Control, which is operated in an identical manner by the bombardier or navigator. When the pilot wishes to transfer control of the airplane to the remote Turn Control he rotates the Control Transfer knob to its extreme clockwise position. This is done slowly to

prevent the sudden introduction of a strong signal in case the remote Turn Control is not centered at the time of transfer. (Never leave transfer knob at an intermediate position.) An indicator light adjacent to the Control Transfer knob informs the pilot when the remote Turn Control is in control of the airplane.

i. DASHPOT ADJUSTMENTS—The dashpot on the Directional Panel is linked to the rudder pickup pot wiper in the Directional Panel in such a way that it produces an extra initial rudder correction signal proportional to the speed of turn axis deviation. This action is required for proper rudder control. Incorrect dashpot adjustment produces a tendency for the airplane to "wallow" or "rudder hunt" even with sensitivity, ratio, and turn compensation properly adjusted. To correct dashpot adjustment, proceed as follows:

(1) Unlock dashpot adjustment by turning lock nut lever counterclockwise.

(2) Turn knurled nut up or down until hunting ceases.

(3) Lock adjustment by turning lock nut lever clockwise.

For more complete information concerning Dashpot adjustments see Section 5, paragraph 3 b (3).

5. PILOT'S FLIGHT PRECAUTIONS

a. Always turn off the Autopilot at least 10 minutes before attempting any stunting maneuvers, to allow time for gyros to slow down. If banks greater than 40 degrees are attempted with gyros running near rated speed, the gyros will be damaged by the violent precession caused by striking their stops.

b. During a straight flight of several hours' duration, it is advisable to check the airplane's course at regular intervals to determine whether precession of the Directional Stabilizer gyro has caused the airplane to deviate from its established heading. This precession is caused by the rotation of the earth and the curvature of its surface. When this phenomenon occurs, it is necessary to use the Turn Control to bring the airplane back to its proper heading.

c. It is important that the pilot understand that his PDI instrument provides a true indication at all times of the position of the aileron and rudder pot wipers in the Directional Panel. This is particularly important while engaging the Autopilot system, because at the instant when either the aileron or rudder Servo Units are engaged, the corresponding pot wipers in the Directional Panel must be at the exact electrical centers of their pots, as indicated by the PDI instrument.

SECTION IV DISASSEMBLY, INSPECTION, REPAIR, AND REASSEMBLY

1. GENERAL.

a. The type C-1 Automatic Pilot consists of the following major units: Vertical Flight Gyro; Directional Stabilizer with Directional Panel and Directional Arm Lock attached; three Servo Units; Rotary Inverter; Amplifier; Autopilot Control Panel; and the electrical wires and junction box used to link these units together electrically so that they may function to control the airplane in flight. In order to simplify instructions for the disassembly, inspection, repair, and reassembly of these units, each unit will be treated separately. Although the directional panel and the directional arm lock are mounted on the sides of the directional stabilizer, these units will also be treated separately since they are complete self-contained units.

Note

If disassembly operations are carried out in sequence as outlined in this section, each unit can be completely disassembled. However, in many cases the necessary repairs, or even a complete overhaul, can be made without breaking down each subassembly completely. Strict adherence to the outlined procedure will permit disassembly of major parts first, and disassembly may then be halted at any point beyond which it is unnecessary to go.

b. Each unit of the C-1 automatic pilot is a delicate piece of precision-built equipment and must be handled as such in disassembly, inspection, repair, and reassembly. Assembly of this equipment at the factory is carried on in air-conditioned, dust-free rooms with the aid of the most delicate and accurate balancing and testing equipment available. The same care, the same precision testing, and the same protection from dust and dirt *must* be given this equipment when it is overhauled in the field.

CAUTION

The following rules must be followed when work of any kind is to be done on these units:

(1) Do not remove any cover from any unit of the system until the outside of the unit has been carefully cleaned to remove any oil, dirt, or dust which may have collected on the surface. The cleaning of the outside of the unit should not be done in the room where the unit is to be disassembled.

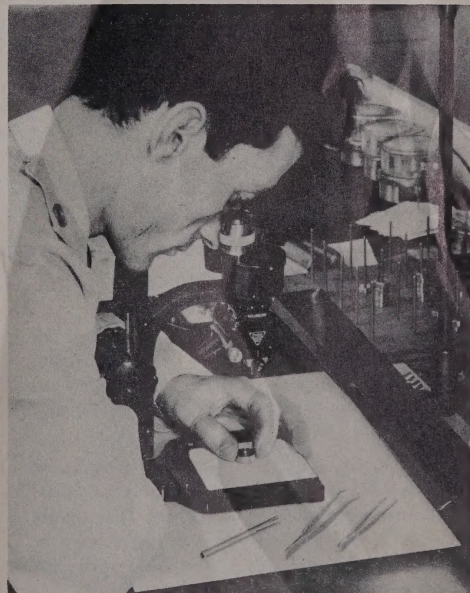


Figure 151 — Examining Bearings Under Microscope and Testing for Cleanliness

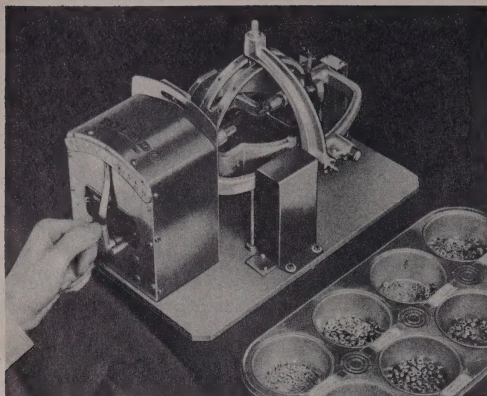


Figure 152 — Testing a Cardan and Bottom Bail for Static Balance

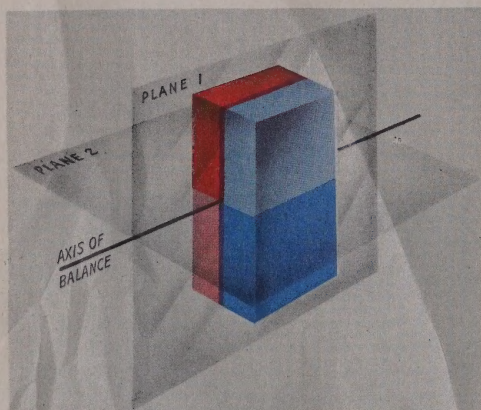
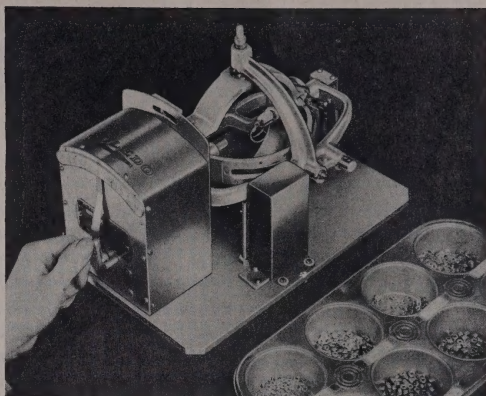


Figure 153 — Planes Intersecting at Right Angles Along Axis of Balance

(2) Do not remove the covers from any of the units or attempt to perform any disassembly, repair, or reassembly operations on them except in a completely enclosed, dust-free, and moisture-free room.

(3) Do not attempt to disassemble, repair, or reassemble units of the automatic pilot unless the necessary tools are available. If an ounce scale is not available, a gram gage may be substituted. Roughly, 28 grams equal one ounce.

(4) Do not attempt to replace any part of any unit without first carefully checking the fit of this part with its related part. The clear-

ance between parts and the tolerances maintained in the manufacture of these units are so small that parts are not generally interchangeable. All bearings, and many other parts, for example, are a selected fit, and it may be necessary to test-fit a large number of these parts at each point where replacement is necessary before a part which will fit exactly is obtained.

2. VERTICAL FLIGHT GYRO.

a. GENERAL.

(1) BEARINGS.

(a) As explained under gyroscope theory in section II, paragraph 2, (1), any force applied to the gyro will cause it to precess at right angles to the direction of the force applied and in direction of rotation. Friction in the bearings on which the unit is mounted applies a force to the gyro which will cause it to precess in exactly the same way as if that force were applied by pressing against the gyro in that direction. Thus, too much bearing friction will cause the gyro to precess from its vertical position so that it cannot control the airplane properly.

(b) The ball bearings on which the gyro is mounted are the finest precision bearings obtainable, designed to have as little frictional drag as possible. However, like any other bearings, improper handling, misuse, or the accumulation of dirt in the bearings will cause rough spots or additional drag which will make the bearing unsatisfactory for use in this unit. Dirt on any other portion of the gyro may easily be blown into the bearings; therefore, it is important to keep the entire gyro and the air in the room in which the gyro is

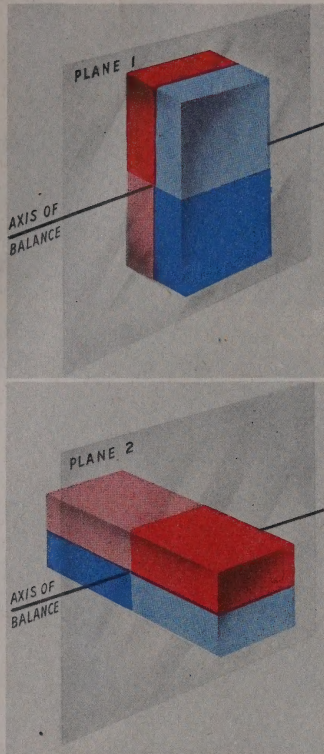


Figure 154 — Static Balance About Plane I and Plane II

being repaired completely free from dust, dirt, and moisture.

(c) After cleaning at the factory, each bearing is examined under a microscope, as shown in figure 151, to make certain that there is no visible dirt to impair its operations and that the bearing races are free from small indentations caused by abuse. A testing machine similar to that shown in figure 151 is used to determine rough spots in the bearings caused by fine particles of dirt, balls which are not round, or races which are not smooth. All bearings are kept in covered containers until the moment at which they are inserted into the gyro. *A gyro overhauled in the field cannot be expected to perform properly unless similar care is given in cleaning and inspecting bearings, and in preventing dirt or dust from entering them.*

(2) BALANCE.

(a) Static unbalance will also cause the gyro to precess from its vertical position in the same way as will bearing friction, since the extra weight on the heavy side is applying a force to the gyro. In manufacture, the rotor and case assembly, the cardan and bottom bail assembly and the top bail and counterbalance guide channel are all balanced separately on accurate precision balancing machines, as shown in figure 152. Then, as these parts are assembled, they are again balanced as one assembly. In overhauling this equipment in the field, similar precision balancing machines will ordinarily not be available. It is imperative, then, that *more than ordinary care* be exercised in performing the static balancing operations outlined in the reassembly procedure so that the gyro will function properly.

(b) A unit is statically in balance if two planes intersecting each other at right angles along the line of the axis each divide the weight of the unit equally. (See figure 153.) Therefore, it is possible to test for static balance about any given axis with the unit supported so that it is "free" (no friction) to turn about that axis. To make this test, *first* check to see that it is stable (has no tendency to tip) when one plane (Plane 1) containing the axis is vertical (figure 154); *second*, check to see that it is stable when a second plane (Plane 2) at right angles to the first plane and also containing the axis is vertical (figure 154). If it is stable in both of these positions, *then* each plane is dividing the weight of the unit equally *and the unit is in static balance about this particular axis*. An unbalanced unit may be balanced about this axis by adding weight at various points on the unit until the condition outlined above exists.

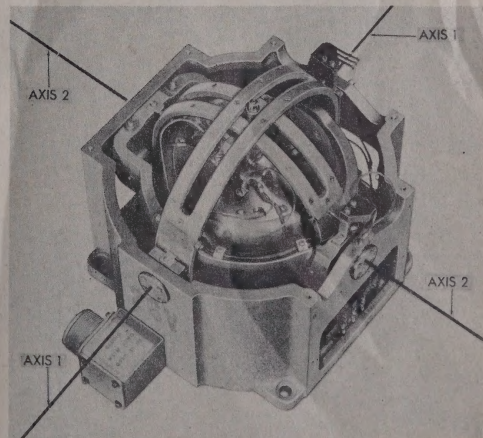


Figure 155 — The Two Axes of Balance

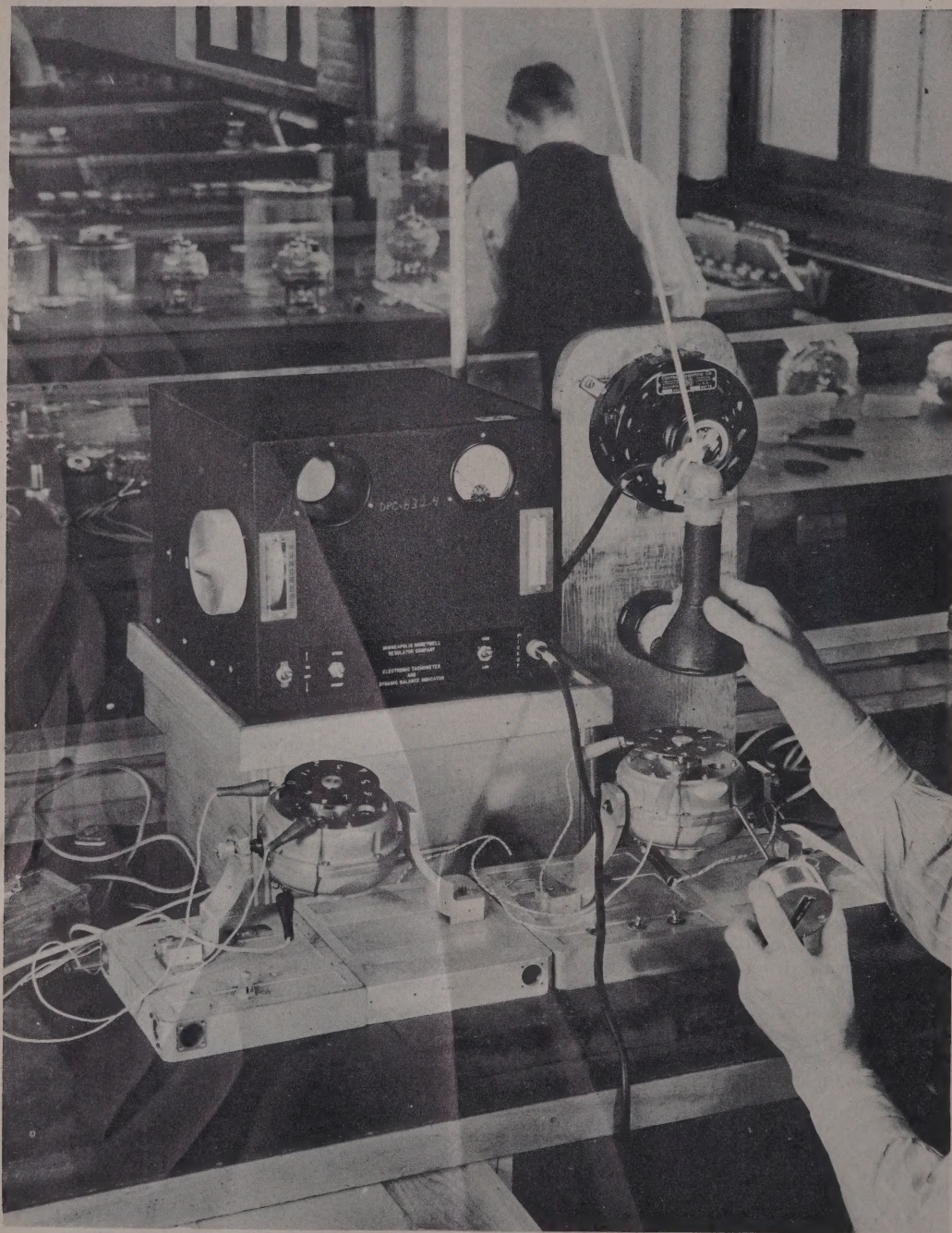
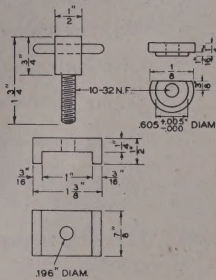
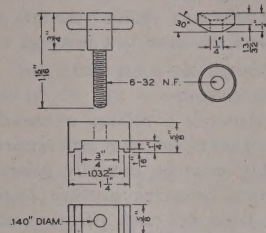


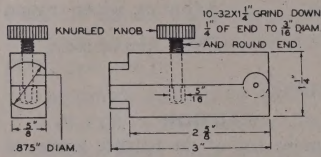
Figure 156 — Dynamic Balancing of Gyro Rotor



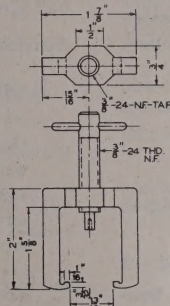
CARDON
BEARING PULLER



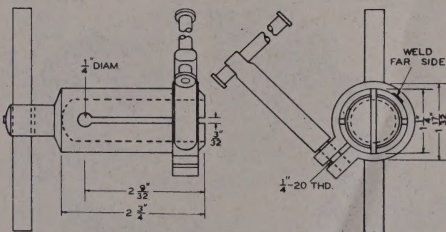
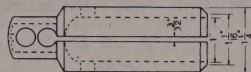
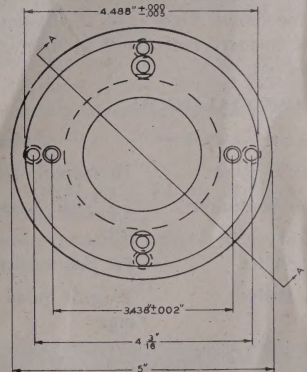
GUIDE CHANNEL
BEARING PULLER



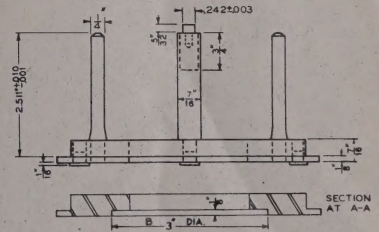
ROTOR CASE
SPREADERS



ERECTING CUTOUT
GEAR PULLER



GUDGEON PIN PULLER



ROTOR CASE STAND

Figure 157 — Special Tools

Section IV
Paragraph 2

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(c) To prevent unbalance from precessing the gyro from its vertical position, the gyro *must* be statically in balance around each of the *two axes* about which it is free to rotate. (See figure 155.) These two axes are as follows:

Axis 1—A line through the exact centers of the counterbalance guide channel bearings and the rotor case bearings.

Axis 2—A line through the exact centers of the cardan bearings.

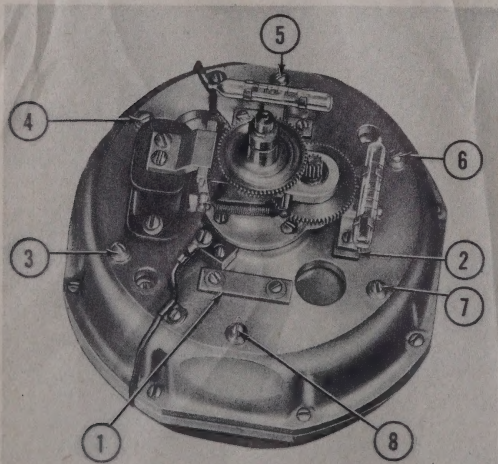
(d) Dynamic balance is a balance of rotating weight and therefore applies to the rotor and armature assembly. This assembly must be carefully balanced dynamically in a dynamic balancing machine (figure 156), as any slight unbalance will cause vibration when the assembly is rotating at the operating speed of 7000 to 7800 revolutions per minute.

b. OVERHAUL TOOLS REQUIRED. (See figure 157.)

(1) The following is a typical list of special tools for use in disassembly, inspection, repair, and reassembly of the vertical flight gyro, in addition to an assortment of standard tools, such as screw drivers, pliers, wrenches, etc.

(2) SPECIAL TOOLS.

Nomenclature	Application
Rotor Case Stand	To support rotor case
Gudgeon Pin Puller	To pull housing gudgeon pins
Bearing Puller	To pull cardan bearings
Bearing Puller	To pull guide channel bearings



Puller	To pull erecting cut-out gear
Spreaders	To separate rotor case halves
Ohmmeter	For tests
0-16 oz. Spring Balance	Adjusting motor brushes
Thickness Gage	Aligning rotor spindle
Taper Gage	Checking end play
Master Level Gage	Setting level vials, etc.
Leveling Plate	Setting level vials, etc.
Aligning Jig (top) (See figure 210.)	Checking alignment of rotor spindle
Aligning Jig (bottom) (See figure 210.)	Checking alignment of rotor spindle
Seating Pins	To reseal rotor bearings
0-10 Gram Gage	Adjusting wiper tension and checking spindle drag
0-25 Gram Gage	Adjusting wiper tension
Strobotac	Check rpm of rotor

c. DISASSEMBLY.

CAUTION

Do not remove any of the balance screws or weights indicated in figures 158, 159, 160, 188 in disassembly. These weights and screws serve only to give proper static balance, as explained in this section, paragraph 2, c, (22), (23), and (25). Their removal in overhauling the gyro will only make static balancing more difficult.

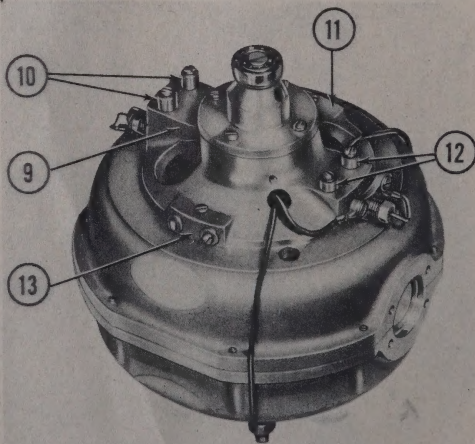


Figure 158 — Location of Balancing Screws and Weights on Rotor Case

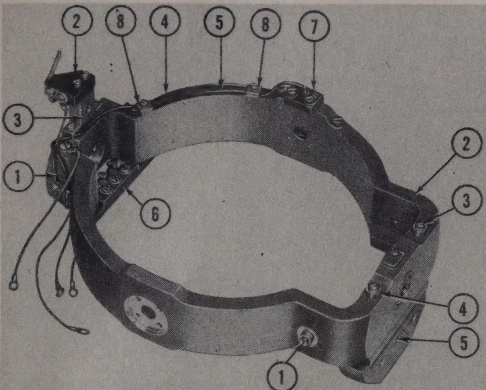


Figure 159 — Location of Balancing Screws and Weights on Cardan

Note

Place all parts in marked sections of tray so that parts may be easily identified at any time.
(See figure 161.)

(1) REMOVE HOUSING COVER, BOTTOM PLATE, AND SIDE COVER PLATES.

(a) (See figure 162.) Remove shock mounting grommets (20) and ground lead wire (21).

(b) Remove the four fillister-head screws (19) holding bottom plate (18) in place, and remove bottom plate.

(c) (See figure 163.) Insert a rotor case stand (1) through bottom opening of gyro housing so that the pins (2) on the stand enter balance screw holes (3)

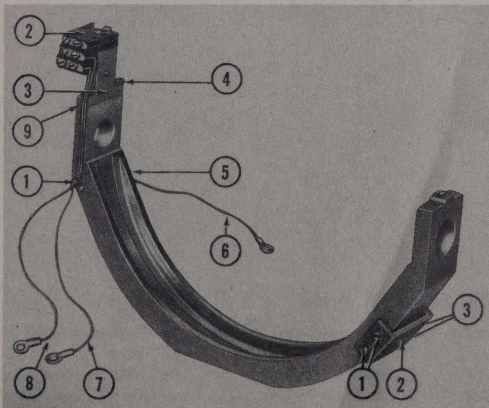


Figure 160 — Location of Balancing Screws and Weights on Counterbalance Guide Channel

on rotor case (4). Set housing upright carefully so that gyro rotor case is supported by the rotor case stand.

(d) (See figure 162.) Remove the six screws (1) securing gyro housing top cover assembly to gyro housing, and remove cover (9). It is not necessary to remove window (3) or shipping cover assembly (4), nor is it necessary to remove the potentiometer inspection covers (7) unless desired.

(e) Remove six fillister-head screws (14) from each of the side covers (15) which cover the potentiometers.

(2) REMOVE POTENTIOMETERS.

(a) (See figure 164.) Remove the two terminal screws (17) connecting the two yellow leads (8) from the elevator potentiometer to the triple potentiometer terminal panel (9).

(b) (See figure 183.) Loosen the screw holding the lead wire clamp (6), which secures these yellow leads to the bottom of the housing.

(c) (See figure 164.) Remove two screws (4) from the elevator potentiometer mounting plate (5); remove potentiometer assembly.

(d) Disconnect lead wires to the triple potentiometer terminal panel (9) and the red lead from the up-elevator potentiometer contact assembly (15) to the terminal block (18) on the housing.

(e) Remove two screws (10) holding triple potentiometer terminal panel (9) to housing; remove triple potentiometer assembly.

(f) Re-insert terminal screws on terminal panel (9).

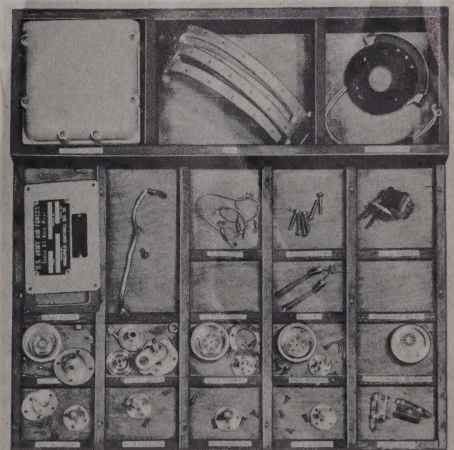


Figure 161 — Tray and Covered Containers for Holding Disassembled Parts

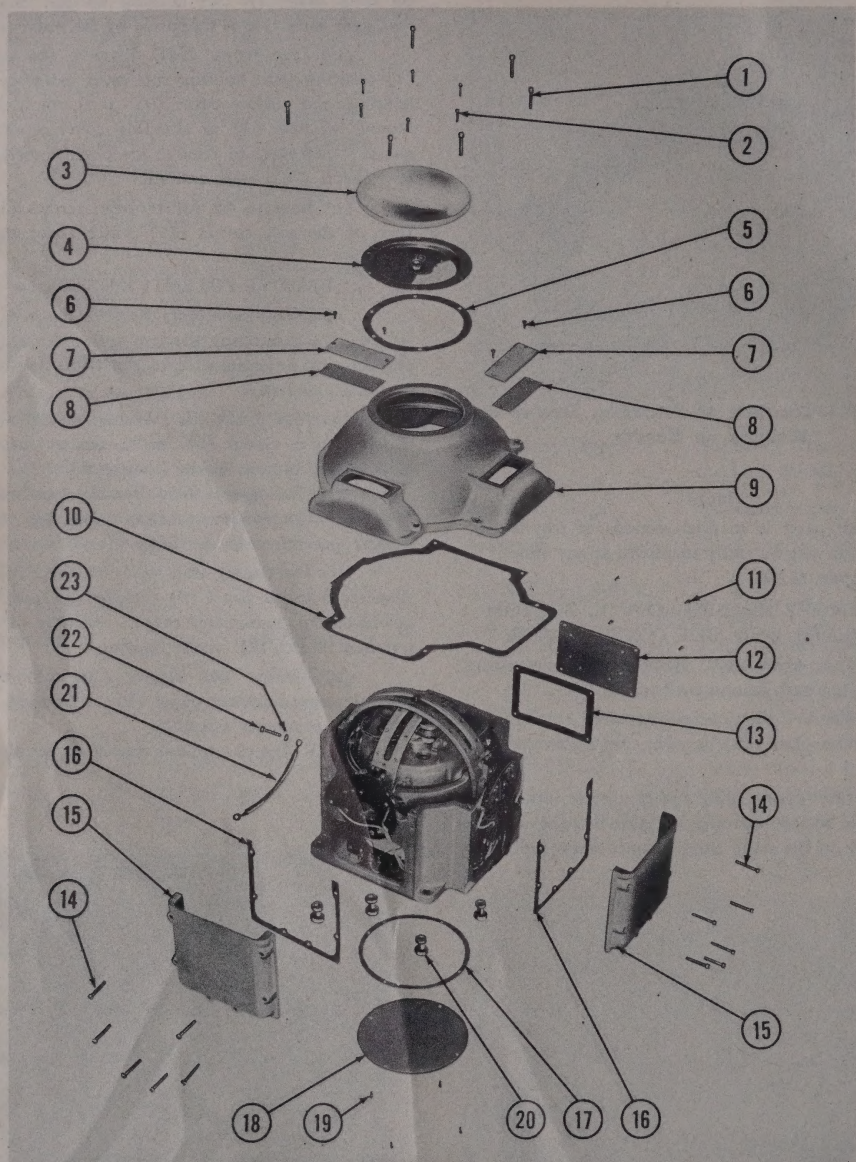


Figure 162 — Gyro Cover, Exploded View

Index No.	Nomenclature	Index No.	Nomenclature	Index No.	Nomenclature	Index No.	Nomenclature
1	Screws	7	Inspection Cover	13	Gasket	19	Screws
2	Screws	8	Gasket	14	Screws	20	Mounting Grommet
3	Window	9	Housing Cover	15	Cover Plate	21	Ground Lead Wire
4	Shipping Cover	10	Cover Gasket	16	Gaskets	22	Screw
5	Gasket	11	Screws	17	Gasket	23	Washer
6	Screws	12	Identification Plate	18	Bottom Cover Plate		

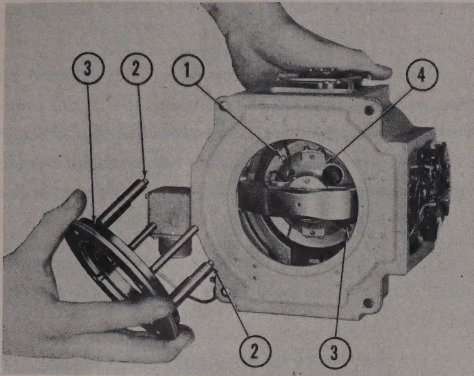


Figure 163 — Inserting Rotor Stand Through Housing

Index No.	Nomenclature
1	Rotor Case Stand
2	Pins
3	Balance Screw Holes
4	Rotor Case

(3) DISASSEMBLY OF POTENTIOMETERS.

(See figure 164.)

(a) Potentiometers must be handled with extreme care unless it is obvious that they must be replaced. (Refer to this section, paragraph 2 d (5).)

(b) The blocks (3 and 11) into which the potentiometer windings are cemented may be removed by removing the three screws (1 and 13) holding them to the assembly. If the potentiometers are defective, the complete assembly may be replaced.

(c) Contact assemblies (14 and 15) on the up-elevator potentiometer and skid potentiometer may be removed by removing the two adjusting screws (16) which hold each contact assembly in place. These contacts should not be removed in disassembly unless they are to be replaced.

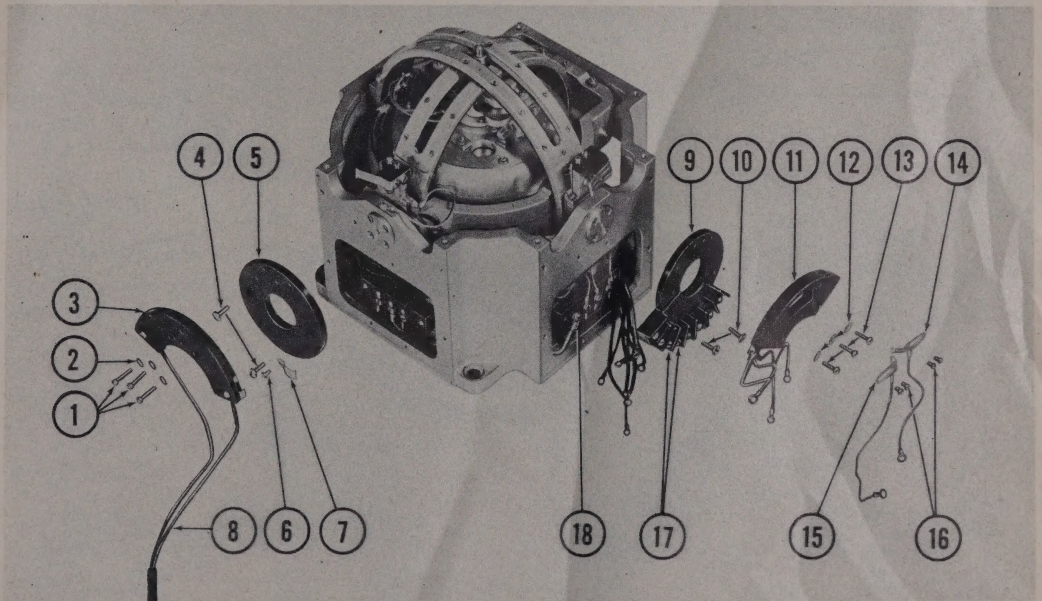


Figure 164 — Potentiometer Assemblies, Exploded View

Index No.	Nomenclature	Index No.	Nomenclature	Index No.	Nomenclature
1	Screws	7	Clamp	13	Screws
2	Lock Washers	8	Yellow Leads	14	Contact Assembly
3	Elevator Potentiometer Block	9	Triple Potentiometer Terminal Panel	15	Contact Assembly
4	Screws	10	Screws	16	Screws
5	Potentiometer Mounting Plate	11	Triple Potentiometer Block	17	Terminal Screws
6	Screw	12	Lock Washers	18	Terminal Block

(4) REMOVE TOP AND BOTTOM BAILS.

(See figure 165.)

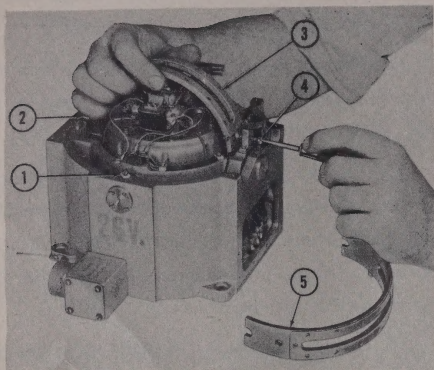


Figure 165 — Removing Erecting Bail

Index No.	Nomenclature	Index No.	Nomenclature
1	Retaining Lug	4	Screw
2	Retaining Lug	5	Top Bail
3	Bottom Bail		

(a) One end of the top bail (5) is retained by means of a retaining lug (1) from one end of the counterbalance guide channel. Loosen the fillister-head screw fastening this retaining lug to the counterbalance guide channel; rotate the retaining lug out of the slot in the top bail (5).

(b) Unscrew the retaining screw at the opposite end of the bail far enough so that the bail may be lifted out.

(c) Loosen the fillister-head screw which fastens the retaining lug (2) for the bottom bail (3) to the cardan; turn the lug aside so that it is no longer over the pin on the bail.

(d) Unscrew the retaining screw (4) in the wiper block assembly on the opposite side far enough to clear the bottom bail; lift out the bottom bail.

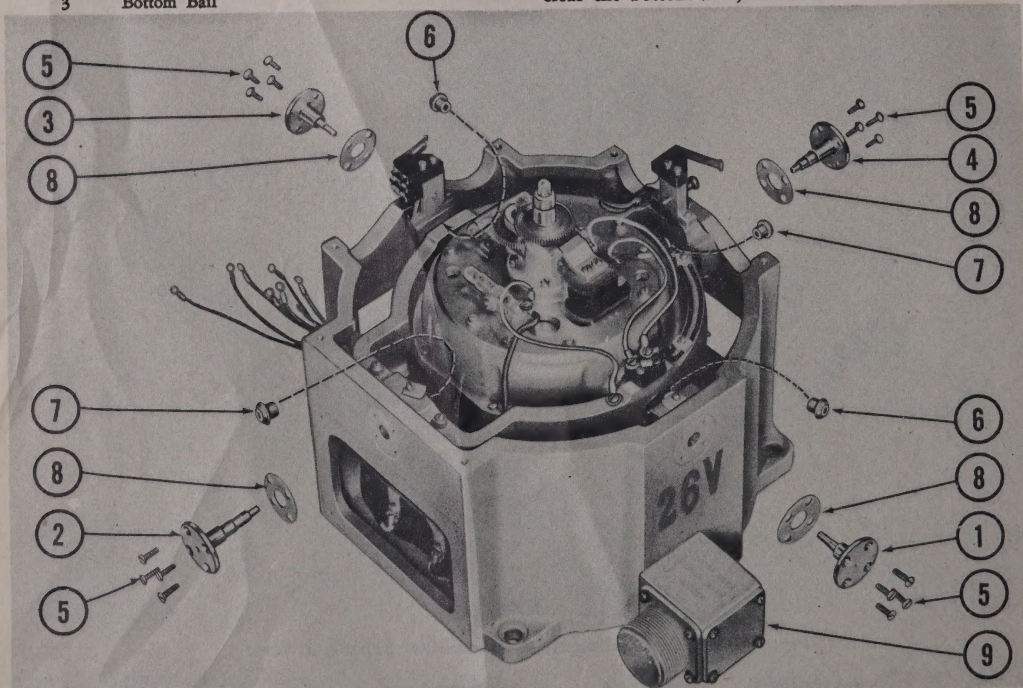


Figure 166 — Housing Gudgeon Pins, Exploded View

Index No.	Nomenclature	Index No.	Nomenclature	Index No.	Nomenclature
1	No. 1 Gudgeon Pin	4	No. 4 Gudgeon Pin	7	Bail Bushings (Bottom)
2	No. 2 Gudgeon Pin	5	Screws	8	Shims
3	No. 3 Gudgeon Pin	6	Bail Bushings (Top)	9	AN Receptacle

(5) REMOVE ROTOR CASE AND CARDAN
ASSEMBLY AND COUNTERBALANCE
GUIDE CHANNEL FROM HOUSING.

CAUTION

Each bail bushing must be kept with the gudgeon pin to which it has been fitted in assembly. For convenience, the four gudgeon pins may be considered numbered in a clockwise direction when looking down on the top of the housing, with gudgeon pin No. 1 located over the AN connector. When gudgeon pins are removed, these bail bushings may be placed on the gudgeon pin from which they were removed, and each gudgeon pin and bushing placed in a marked section of a tray, with the number showing the position from which it was removed.

(a) (See figure 167.) Scribe top of each gudgeon pin to mark the top and also the position (Nos. 1, 2, 3, and 4, Figure 166).

(b) (See figure 166.) Using a pair of tweezers, remove the bottom bail bushings (7) from the gudgeon pins (Nos. 2 and 4).

(c) (See figure 167.) Disconnect cardan-to-housing ground lead (4) from the housing.

(d) Disconnect the three flex leads (5) leading from the cardan terminal block to the gyro housing terminal block (6).

(e) (See figure 166.) Remove the four flathead screws (5) from gudgeon pin No. 2 (2).

(f) Remove the four flathead screws (5) from gudgeon pin No. 4 (4).

(g) Remove gudgeon pins Nos. 2 and 4 from housing, being careful to keep any shims (8) with the gudgeon pin under which they were found. (These shims provide alignment and end play adjustments. There may be shims under any, all, or none of the pins.) Place gudgeon pins Nos. 2 and 4 in marked sections of a tray, with the bottom bail bushings (7) previously removed. Gudgeon pins may usually be pushed out with the fingers; but if tight fits are encountered, a puller may be used. (See figure 168.)

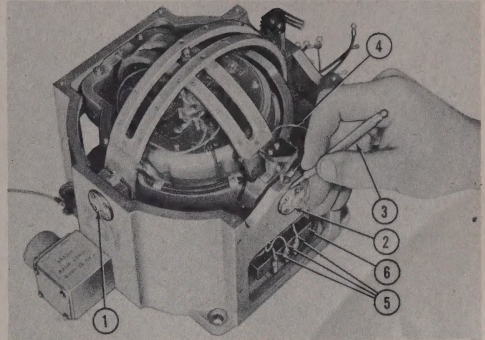


Figure 167 — Scribing Gudgeon Pins for Identification

Index No.	Nomenclature
1	Gudgeon
2	Gudgeon
3	Scribing Tool
4	Housing Ground Lead
5	Flex Leads
6	Terminal Block

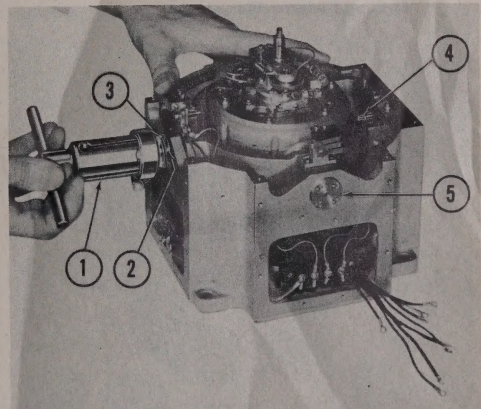


Figure 168 — Removing Gudgeon Pins With Puller

Index No.	Nomenclature
1	Puller
2	Gudgeon
3	Gudgeon Shims
4	Gudgeon
5	Gudgeon

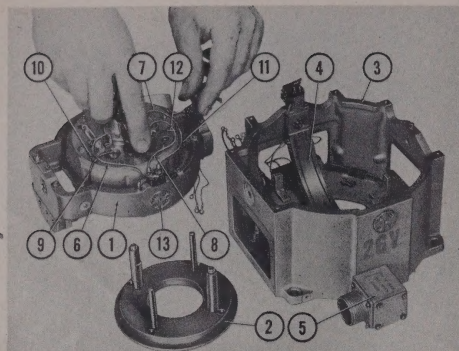


Figure 169 — Lifting Rotor and Case and Cardan Assemblies from Housing

Index No.	Nomenclature
1	Cardan
2	Rotor Case Stand
3	Housing
4	Counterbalance Guide Channel
5	AN Receptacle
6	Cardan Ground Lead
7	Motor Flex Lead
8	Cutout Flex Lead
9	Field Coil Ground Lead
10	Clamps
11	Motor Flex Lead
12	Field Coil Lead
13	Gudgeon Pin

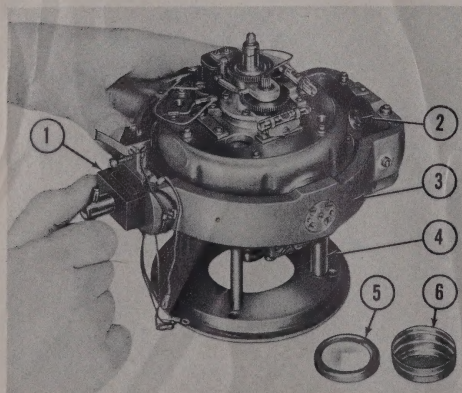


Figure 170 — Pulling Cardan Bearing

Index No.	Nomenclature
1	Bearing Puller
2	Cardan Bearing
3	Cardan
4	Rotor Case Stand
5	Container Cover
6	Container

(b) (See figure 169.) Grasp rotor and case and cardan assembly by the erecting cut-out gears with one hand; and, steadying cardan with the other, lift the assembly from the housing. Remove rotor case stand (2) from under the gyro housing; place under rotor case.

(i) (See figure 166.) Using a pair of tweezers, remove top bail bushings (6) from gudgeon pins Nos. 1 and 3; place in marked sections of tray.

(j) Disconnect flex leads leading from counterbalance guide channel to the gyro housing terminal block.

(k) Remove four flathead screws (5) from gudgeon pin No. 1 (1).

(l) Remove four flathead screws (5) from gudgeon pin No. 3 (3).

(m) Remove gudgeon pins Nos. 1 and 3 from gyro housing; place in marked sections of tray with bail bushings Nos. 1 and 3.

(n) (See figure 169.) Lift out counterbalance guide channel (4).

(6) REMOVE BEARING FROM CARDAN AND COUNTERBALANCE GUIDE CHANNEL.

(See figure 170.)

(a) Insert disc from cardan bearing puller (1) inside a cardan bearing; screw the puller pin into it from the other side. Remove the bearing by screwing up on the bearing puller handle.

(b) Remove second cardan bearing (2) in the same manner.

(c) Using a guide channel bearing puller, remove the bearings from counterbalance guide channel in this same manner.

CAUTION

As each bearing is removed, place it in a covered container (5 and 6), properly marked, so that in reassembly it may be replaced in the same position from which it was removed. In placing bearings in containers, *place the side of the bearing which was toward the outside of the bearing bore up* so that it will not be upside down when replaced. All shims found under the bearings must be placed with the bearings in the covered containers. Each of these bearings is carefully fitted into the bore of the cardan or guide channel and onto its gudgeon pin. Therefore, bearings replaced in a different location, or in a different position than they occupied before disassembly, may result in misfits, improper operation of the gyro, and loss of time in reassembly.

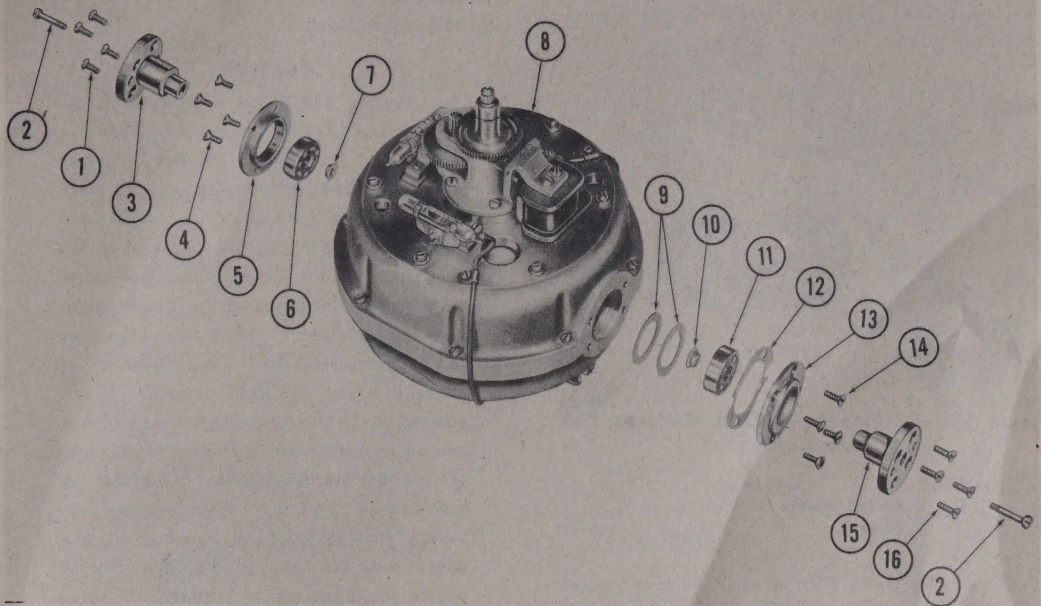


Figure 171 — Rotor Case Bearings, Exploded View

Index No.	Nomenclature	Index No.	Nomenclature	Index No.	Nomenclature
1	Screws	7	Locking Plug	13	Bearing Socket
2	Locking Screws	8	Rotor Case	14	Screws
3	Gudgeon Pin	9	Shims	15	Gudgeon Pin
4	Screws	10	Locking Plug	16	Screws
5	Bearing Socket	11	Bearing (Locked)		
6	Bearing (Free)	12	Shims		

(7) REMOVE ROTOR AND CASE ASSEMBLY FROM CARDAN ASSEMBLY.

(a) (See figure 169.) Disconnect both ends of rotor case-to-cardan ground lead (6) and remove flex lead. Disconnect both ends of motor flex lead (7) and erecting cut-out flex lead (8) and remove flex leads.

(b) (See figure 171.) Scribe top of both gudgeon pins (3 and 15) securing rotor and case assembly in cardan assembly.

Note

The gudgeon pin (15) on the same side as the erecting cut-out magnet is marked "F," which designates it as the locked bearing. This bear-

ing is locked to the rotor case by the shims (9) and the bearing socket (13), and to the cardan by the locking plug (10) and the gudgeon pin (15). The gudgeon pin (3) on the side opposite the erecting cut-out magnet is marked "R" to designate it as the free bearing. This bearing is locked to the cardan by the locking plug (7) and the gudgeon pin (3), and is free to slide in the bearing socket (5).

(c) Loosen the two locking screws (2) located in the center of the gudgeon pins (3 and 15) which lock the bearings (6 and 11) to the pins (3 and 15).

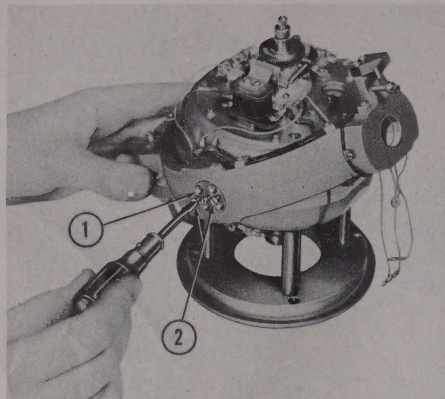


Figure 172 — Pulling Rotor Case Gudgeon Pins from Cardan

Index No.	Nomenclature
1	Locked Bearing Gudgeon Pin
2	Screws

(d) (See figure 172.) Remove the four flathead screws (2) from the locked bearing gudgeon pin (1); replace two of them in the puller holes. Turn in first one screw and then the other until the gudgeon pin loosens.

(e) Remove the four flathead screws from the free bearing gudgeon pin; replace two of them in the puller holes. Turn in one screw and then the other until the gudgeon pin loosens.

(f) Remove both gudgeon pins; place in marked section of tray.

CAUTION

In removing gudgeon pins, be sure to support cardan so that one side does not fall down when pin is removed. This may damage the bearing which has not been removed.

(8) REMOVE BEARINGS FROM ROTOR CASE.

(See figure 171.)

(a) Scribe the top edge of both bearing sockets (5 to 13) and the rotor case at this point.

(b) Remove the four flathead screws (14) which secure the locked bearing socket (13) to the rotor case (8).

(c) Remove locked bearing socket (13) and bearing (11). Socket may or may not have threaded

holes into which screws may be inserted for pulling. If no holes are found, carefully insert knife blade under edge of flange to loosen it.

CAUTION

Place bearing and socket together with all shims (9 and 12) found under socket and under bearing (11) into a covered container, properly marked for identification, and place in tray with gudgeon pin. These shims were placed under the bearing and under the socket to properly lock the bearing in place and center the rotor case in the cardan for proper alignment and balance. To simplify alignment and balance in reassembly, they should be replaced in exactly the same position. Do not place screws in the covered container with the bearing, as metal particles from the screws may get into the bearing. Be sure to see that the locking plug (10), into which the gudgeon locking pin (2) screws, is placed in the container with the bearing. Bearings may be pushed out of socket for cleaning.

(d) Remove the four flathead screws (4) from the free bearing socket (5). Remove free bearing socket and bearing. Bearing socket may or may not have threaded holes into which screws may be inserted for pulling. If not, insert knife edge to loosen the socket. Bearing must be placed in covered container. (See CAUTION above.)

(9) REMOVE ERECTING CUT-OUT MECHANISM.

(a) Install erecting cut-out puller (1, figure 174) with the claws under the cut-out roller gear (3), taking care that claws do not touch the fingers on the gear actuating arm (5, figure 173). Screw down on puller handle to remove upper erecting roller (11), roller gear (13), and the snap rings (10 and 12) which hold them in place on the spindle. If puller is not available, snap rings may be removed with a small screw driver and slipped off.

(b) Disconnect spring (18) from erecting cut-out mechanism.

(c) Remove the two fillister-head screws (1) securing the erecting cut-out armature bracket assembly and magnet (8) to the rotor case; remove the complete erecting cut-out armature bracket assembly and magnet and magnet base (9).

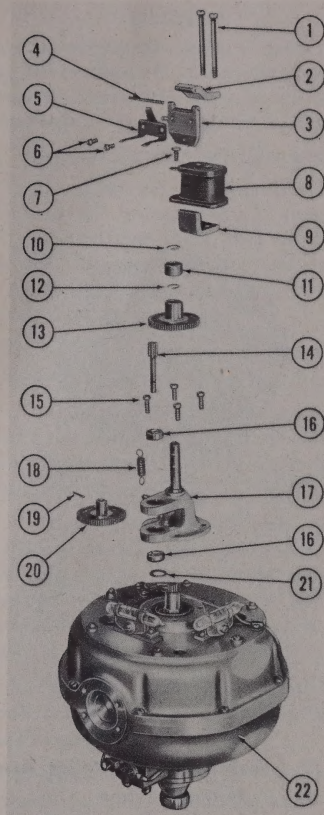


**Figure 173 — Erecting Cutout Mechanism
Exploded View**

Index No.	Nomenclature
1	Screws
2	Bracket
3	Armature Assembly
4	Hinge Pin
5	Actuating Arm
6	Screws
7	Screw
8	Magnet
9	Magnet Base
10	Snap Ring
11	Upper Erecting Roller
12	Snap Ring
13	Roller Gear
14	Pinion Shaft
15	Screws
16	Bearings
17	Gear Frame Assembly
18	Spring
19	Tapered Pin
20	Intermediate Gear
21	Spacer
22	Rotor Case

(d) Using a small pin punch and hammer, drive out the tapered pin (19) which secures the bronze intermediate gear (20) to the intermediate pinion shaft (14). Be sure to drive only on the small end of the tapered pin. Remove pin with tweezers.

(e) Pull out intermediate pinion and shaft (14); remove intermediate gear (20). A spacing collar is sometimes used under this intermediate gear and must be kept with the gear.

(f) Remove the four fillister-head screws which fasten the erecting cut-out gear frame assembly to the rotor case (22); remove erecting gear frame assembly. Shims may have been placed under the erecting gear frame assembly to provide the proper end play of the rotor in the case. Be sure to keep these shims, properly marked, with the erecting gear frame assembly.

(g) Press out bearings (16) from erecting gear frame, with bar of the same diameter as the bearings.

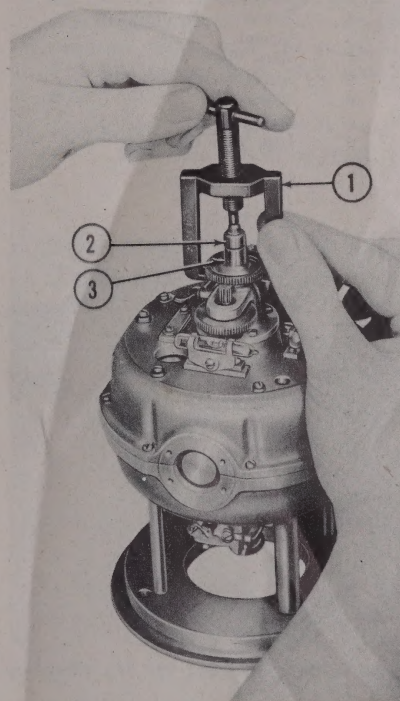


**Figure 174 — Using Puller to Remove Erecting
Cutout Roller Gear and Roller**

Index No.	Nomenclature
1	Puller
2	Upper Erecting Roller
3	Cutout Roller Gear

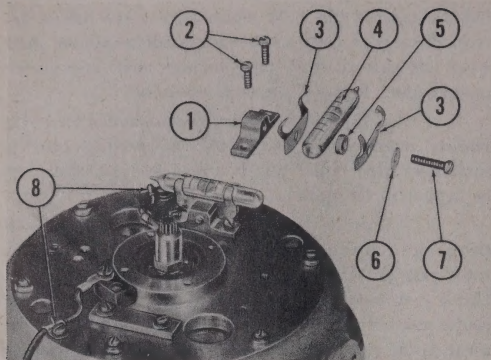


Figure 175 — Rotor Case Level Vial, Exploded View

Index No.	Nomenclature
1	Vial Bracket
2	Screws
3	Clamps
4	Glass Vial
5	Spacer Washer
6	Washer
7	Screw
8	Lead Wire Clamp

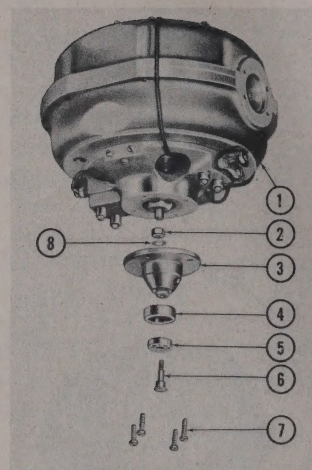


Figure 177 — Guide Channel Roller Assembly, Exploded View

Index No.	Nomenclature
1	Rotor Case
2	Nut
3	Roller Cap
4	Roller
5	Roller Bearing
6	Screw Stud
7	Screws
8	Washer

The spacer (21) under the lower bearing will come out with the bearing.

(10) REMOVE LEVELING VIALS AND BRACKETS. (See figure 175.) Loosen the clamping screw (7) securing each vial; pull the glass vial (4) from between the clamps (3). Remove the two fillister-head screws (2) securing the leveling vial bracket (1) to the rotor case; remove the bracket.

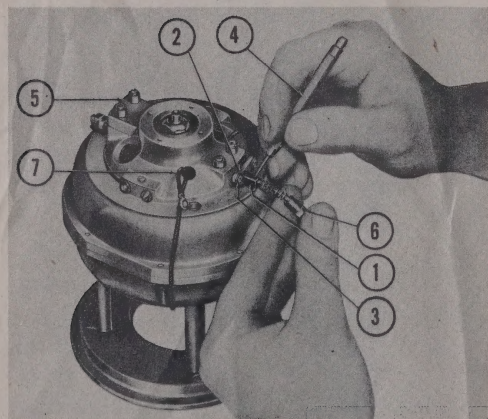


Figure 176 — Scribing Brushes for Identification

Index No.	Nomenclature
1	Brush
2	Brush Holder
3	Screws
4	Scribing Tool
5	Lead Weight
6	Brush Holder Plug
7	Field Coil Lead

CAUTION

Balancing weights may be found under the leveling vial brackets. If such weights are found, replace the screws, after removing the brackets so that balance weights will not be disturbed.

(11) REMOVE ROTOR FROM CASE.

(a) (See figure 169.) Disconnect field coil lead (12) and field coil ground lead (9) from the small terminal block and from the ground screw on top of the rotor case. Loosen two fillister-head screws in the clamps (10) securing these leads to the top of the case; remove leads from under the clamps.

(b) Turn rotor and case assembly over on stand; remove brushes. (See figure 176.)

1. Disconnect the field coil lead (7) and the brush lead from the brush holder terminal on the side opposite the heavy lead weight (5) which balances the weight of the erecting cut-out.

2. Scribe this brush holder with a single mark, unscrew brass adjusting screw (6), and as the brush (1) is pulled out of the holder, scribe the top surface of the carbon brush with a single mark also. This will permit reassembling of the correct brush in the correct position.

3. Disconnect field coil lead and brush lead from brush holder terminals on the side next to the heavy lead weight.

4. Scribe brush holder on this side with two marks, unscrew brass brush adjusting screw, and as the brush is removed, scribe the top of the carbon brush with two marks also.

(c) Remove guide channel roller assembly. (See figure 177.)

1. Scribe edge of guide roller cap (3) and rotor case (1) so that in reassembly the guide roller cap may be properly located.

2. Remove the four fillister-head screws (7) which secure the guide channel roller assembly to the rotor case.

3. Remove guide channel roller assembly. If assembly does not lift off easily, insert pin punch of the proper size in one of the side holes, and rotate assembly to remove. Do not use screw driver, or other blunt instrument, under the edge of this assembly, as it may damage the assembly or the rotor case.

4. Using a socket wrench, remove the nut (2) and flat washer (8) on the screw stud (6) securing the guide roller bearing (5) to the guide roller cap (3). If this stud fits tightly, it may be necessary to tap it

out with a fiber drift pin so as not to damage the threads.

5. Remove bearing (5) from roller (4), using small pins through the holes provided to push against the outer bearing race if necessary.

(d) Separate halves of rotor case.

1. (See figure 179.) Remove the eight fillister-head screws (1) holding the two halves (2 and 8) of the rotor case together.

2. (See figure 178.) Insert rotor case spreaders (1) into bearing recesses on each side of case; separate the two halves (2 and 3) of the rotor case.

(e) (See figure 179.) Remove rotor assembly from the case.

CAUTION

The highly polished surface of rotor is covered by a thin film of oil which prevents rust. Do not handle this rotor any more than necessary; after handling, always wipe off rotor with cloth moistened with a small amount of light oil. It is best to use gloves when handling the rotor.

(12) REMOVE ROTOR BEARINGS AND ARMATURE FROM ROTOR.

(See figure 180).

CAUTION

Do not remove bearing locking nuts (1 and 7), bearings (2 and 6), or balancing screws (8) from rotor unless dynamic balancing equipment is available. This assembly has been

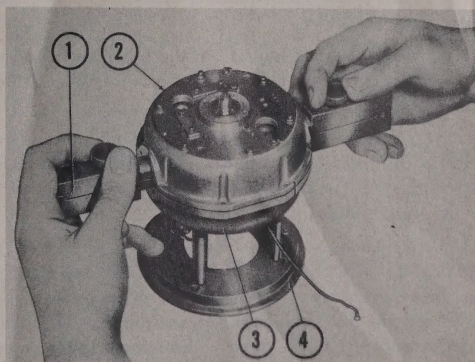


Figure 178 — Separating Halves of Rotor Case

Index No.	Nomenclature
1	Case Spreaders
2	Upper Half of Housing
3	Lower Half of Housing
4	Rotor Case Stand

carefully dynamically balanced on a dynamic balancing machine (*figure 156*) and will not operate satisfactorily unless it remains in balance. It is recommended that balancing screws be left in the rotor, since their removal will make subsequent dynamic balancing more difficult.

(a) Using a $\frac{3}{8}$ -inch wrench, loosen the lock nut and pinion assembly (1) securing the upper rotor bearing (2) to the rotor shaft. Extreme care should be used in removing this lock nut assembly so that the teeth on the pinion, which is a part of this nut, are not damaged.

(b) Pull off top rotor bearing (2) and place in covered container. If bearings cannot be removed by hand, they may be forced off in an arbor press, but must then be discarded, since force will ruin the bearings.

(c) Loosen lock nut (7) holding lower rotor bearing (6) in place. Pull off bearing and place in covered container.

(d) Remove the six fillister-head screws (3) holding the rotor to the armature, taking care to scribe a mark on the rotor and on the shaft to mark their exact position for reassembly.

(e) Remove armature (5) from rotor (4).

(13) REMOVE AND DISASSEMBLE FIELD ASSEMBLY. (*See figure 179.*)

(a) Before removing field assembly, note that two of the field coil leads emerge from the small hole in the housing next to the lower rotor bearing oil hole. The longer of these two leads is the one which connects to the small fiber terminal block on top of the rotor case.

(b) Note that leads from the other coil emerge from holes adjacent to the point where they enter the coil.

(c) Make a scribe mark on the field ring (4) and on the inside of the lower half of the rotor case (8) so that field assembly may be re-assembled in exactly the same position.

(d) Loosen the two fillister-head screws (11) holding the field assembly about two turns; tap lightly on these screws with a soft hammer or wooden block to loosen the field assembly from the case. After the field assembly is loose, remove the screws and remove the assembly from the case.

(e) Place a single scribe mark on the pole piece (6) which passes through the field coil with the longer lead, and a single scribe mark on the field ring on that side. Place two scribe marks on the opposite pole piece and opposite side of the ring.

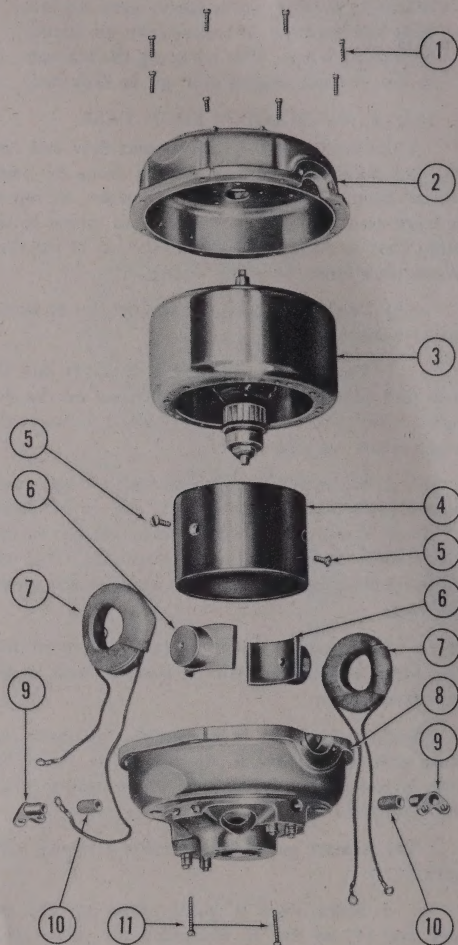


Figure 179 — Rotor and Case Assembly, Exploded View

Index No.	Nomenclature
1	Screws
2	Upper Half of Housing
3	Rotor Assembly
4	Field Ring
5	Screws
6	Pole Piece
7	Field Coil
8	Lower Half of Housing
9	Brush Holder
10	Insulating Tubes
11	Screws

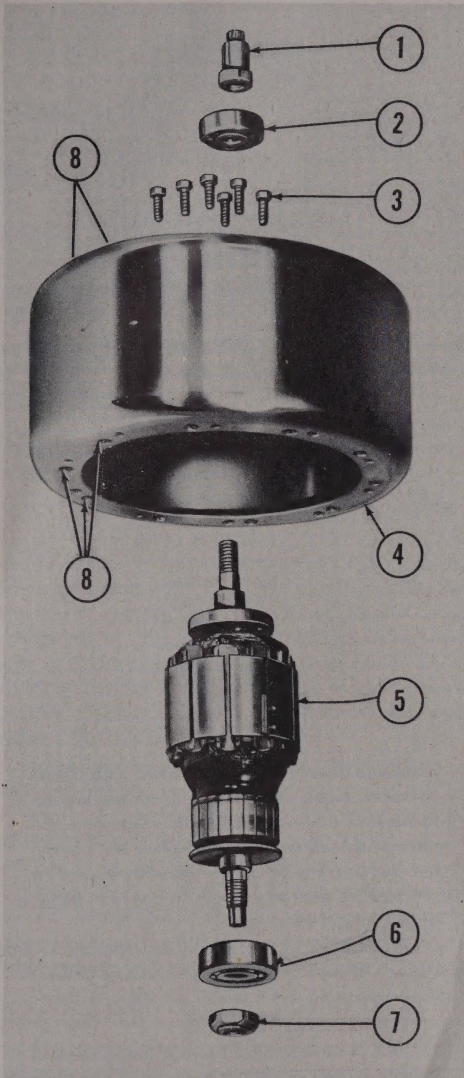


Figure 180 — Rotor Assembly, Exploded View

Index No.	Nomenclature
1	Locking Nut and Pinion Assembly
2	Bearing, Upper
3	Screws
4	Rotor
5	Armature
6	Bearing, Lower
7	Locking Nut
8	Balancing Screws

(f) Remove the flathead screws (5) holding the pole pieces in place and remove the pole pieces and field coils. These screws are staked in place and the metal staked into the screw slots must be sheared off to remove them.

(g) Using a pin through one brush holder (9), push with an arbor press against a small block placed on the opposite brush holder to press it out of the rotor case (8). Remove the second brush holder in the same manner, and slip off insulating tubes (10). Scribe mark brush holders and case for identification in assembly.

(14) REMOVE WIPER, WIRES, AND TERMINAL BLOCKS FROM CARDAN.

(See figure 181.)

(a) Disconnect the lead to the elevator pot wiper blade assembly (2) at the wiper blade terminal.

(b) Remove the two fillister-head screws attaching wiper blade assembly (2) to the wiper block mounting pedestal (3), and remove assembly. Wiper blade may be removed from block by removing the two binding head screws holding it in place.

(c) Remove the two fillister-head screws holding wiper block mounting pedestal to cardan, and remove pedestal.

(d) Remove the three fillister-head screws (8) on clips which secure wires running from the three-

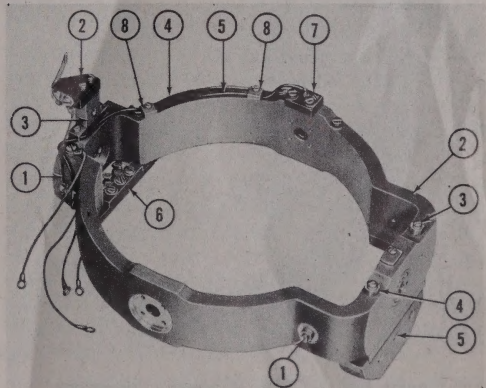


Figure 181 — Cardan Assembly

Index No.	Nomenclature
1	Lead Wire
2	Wiper Mounting Block
3	Mounting Pedestal
4	Lead Wire
5	Lead Wire
6	Three-Terminal Block
7	Two-Terminal Block
8	Clips

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terminal block (6) on the under side of the cardan to the two-terminal block (7) on the top.

(e) Remove the four fillister-head screws securing the two terminal blocks to the cardan, and remove terminal blocks and wires. Wires and flex leads may be removed from terminal blocks by removing screws holding them in place.

CAUTION

In disassembly of cardan, remove only parts mentioned above. Do not disturb counterweights or balance weights attached to the cardan.

(15) REMOVAL OF TRIPLE POT WIPER BLOCK ASSEMBLY FROM COUNTER-BALANCE GUIDE CHANNEL.

(See figure 182.)

(a) Remove three fillister-head screws from clips (1, 4, and 5) holding flex leads (6, 7, and 8) to guide channel. One of these screws also serves to secure wiper pedestal (3) to channel.

(b) Remove the two fillister-head screws holding wiper block assembly (2) to wiper pedestal (3), and remove wiper block assembly.

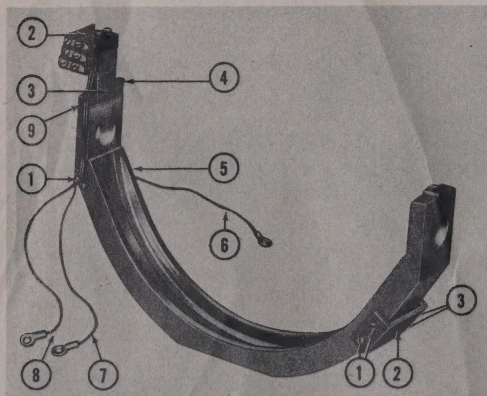


Figure 182 — Guide Channel Assembly

Index No.	Nomenclature
1	Clip
2	Wiper Block Assembly
3	Mounting Pedestal
4	Clip
5	Clip
6	Flex Lead
7	Flex Lead
8	Flex Lead
9	Lead Wires Cemented to Channel

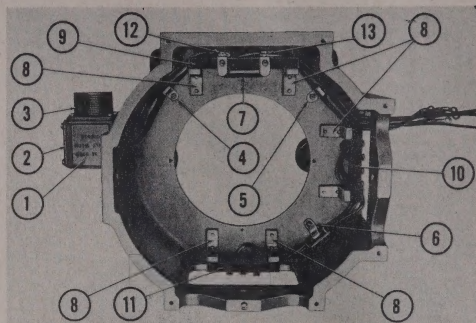


Figure 183 — Housing With Wiring Harness and Terminal Block

Index No.	Nomenclature
1	Adapter
2	Cover Plate
3	AN Receptacle
4	Lead Wire Clamp
5	Lead Wire Clamp
6	Lead Wire Clamp
7	Resistor
8	Block Brackets
9	Terminal Block
10	Terminal Block
11	Terminal Block
12	Terminal Screw
13	Terminal Screw

Note

Although wiper blades are fastened with screws to wiper block, flex lead connections are cemented in place in the block. Therefore, no attempt should be made to replace the blades; but the entire wiper block assembly should be replaced in case of damage to any one blade, or if contacts show wear.

(c) Remove remaining fillister-head screw from wiper block mounting pedestal and remove pedestal.

CAUTION

Do not remove counterbalance guide channel balance weight, as this is a balanced assembly.

(16) REMOVE TERMINAL BLOCKS AND AN RECEPTACLE ASSEMBLY FROM GYRO HOUSING.

(a) (See figure 162.) Remove the four fillister-head screws (11) securing the identification plate (12) to the housing; remove identification plate.

(b) (See figure 183.) Remove the three fillister-head screws attaching wire clips to housing, and remove wire clips (4, 5 and 6).

(c) Disconnect all wires emerging from AN re-

ceptacle assembly from the terminal blocks (9, 10 and 11).

(d) Remove the four fillister-head screws and lock washers securing AN receptacle (3) to adapter (1); remove AN receptacle assembly, being careful not to damage gasket under receptacle.

(e) Remove the four fillister-head screws and lock washers attaching the AN adapter cover plate (2) to the adapter; remove cover plate, being careful not to damage gasket.

(f) Remove the four fillister-head screws and lock washers attaching adapter (1) to housing, being careful not to damage gasket.

(g) Remove the terminal blocks (9, 10 and 11) from terminal block brackets (8) by removing fillister-head screws attaching each block to each gasket.

(h) Remove the 12 fillister-head screws which hold the terminal block brackets to housing and remove the six terminal block brackets.

d. CLEANING, INSPECTION, TESTING, AND REPAIR.

(1) INSPECT BEARINGS.—One of the most important considerations in overhauling a gyro is the care with which bearings are handled and cleaned. Poor bearings set up frictional forces which, as explained under gyro theory in this section, paragraph 2, a, (1), will cause the gyro to precess from its vertical position, and thus make its operation unsatisfactory for maintaining a plane in level flight.

(a) Each bearing must be carefully inspected for small indentations in the outer race, cleanliness, and the fit of the outer race in the bearing bore or socket and the inner race on the pin or shaft. Each bearing is a selected fit for the particular position where it is used. To protect bearings from dirt and to make sure that they will be replaced in the same location from which they were removed, each bearing was placed in a covered container, properly marked to identify it.

(b) In cleaning, testing, and inspecting bearings, be sure that only one bearing at a time is removed from its covered container and that the same bearing is replaced, after cleaning, in this container if it is determined from the inspection and testing that it is suitable for replacement in the gyro. A bearing not suitable for replacement should be discarded. In selecting a replacement bearing, be sure to procure a number of bearings of this type and carefully select the bearing that fits perfectly in the location for which it is to be used.

(c) (See figure 184.) Before bearings are cleaned, they should be checked for fit of the outer race in the socket (1) or bore into which the bearing is to fit. Test fit in one position; then turn bearing over and

test again to determine whether or not any slight taper of the bearing might affect its fit and operation. Placing a pin (3) of the proper diameter into the inner race, as shown, will make fitting of outer race easier. The bearing inner race must also be checked for fit on its gudgeon pin (4) or shaft to make sure that the inner race fits properly.

(d) All bearings should fit snugly enough so that they will not turn on the shaft or in the bore, yet may be pressed into place with the fingers.

(2) CLEANING BEARINGS.—After testing a bearing for proper fit, proceed with cleaning as follows:

(a) All bearings in the vertical flight gyro, with the exception of counterbalance guide channel bearings, the guide roller bearings, and the two small erecting gear bearings, are self-aligning bearings. They may, therefore, be tipped sideways (if rotated slightly) in the outer race for easy cleaning, as shown in figure 185.

(b) In cleaning bearings, use a solution of trichlorethylene (AN-T-37) or L and R cleaning solution, 30-053, 44-10107, stock No. 7300-205700. Immerse the bearing in the cleaning solution and move it about so that the solution moves back and forth between the races and around the bearing balls. Remove the bearing from the cleaning solution, rotate the bearing to a different position and again pass it through the cleaning solution. During the cleaning process, rotate the bearing with the fingers, testing the "feel," to see if small particles of dirt remain in the bearing races. Do not leave the bearing in the washing solution any longer than is necessary. After removing the bearing from the washing solution, rinse the bearings in clean, high-grade kerosene to remove the washing solution from the bearings.

(c) Align the bearing with the outer race; rotate the bearing, using a pin through the inner race, and holding the outer race between the fingers (figure 186). Carefully rotate in this manner to "feel" any rough spots caused by dirt or indentations in the bearing races. A bearing which drags at certain points, or is rough or bumpy to the feel, is either dirty and requires additional cleaning, or must be replaced.

(d) Hold the bearing on the pin in a vertical position; using the thumb against the outer race, spin it slowly to see if it runs evenly. Watch particularly for a bearing which stops suddenly at a particular point and seems to bounce back. This definitely indicates a condition which must be corrected, or that the bearing should be discarded.

(e) The rinsing solution may be blown out of the bearing if care is taken to use *filtered* compressed air and to blow it completely through the bearing. Great care must be taken to be sure that the bearing is not spun by the air, as this will damage the bearing.

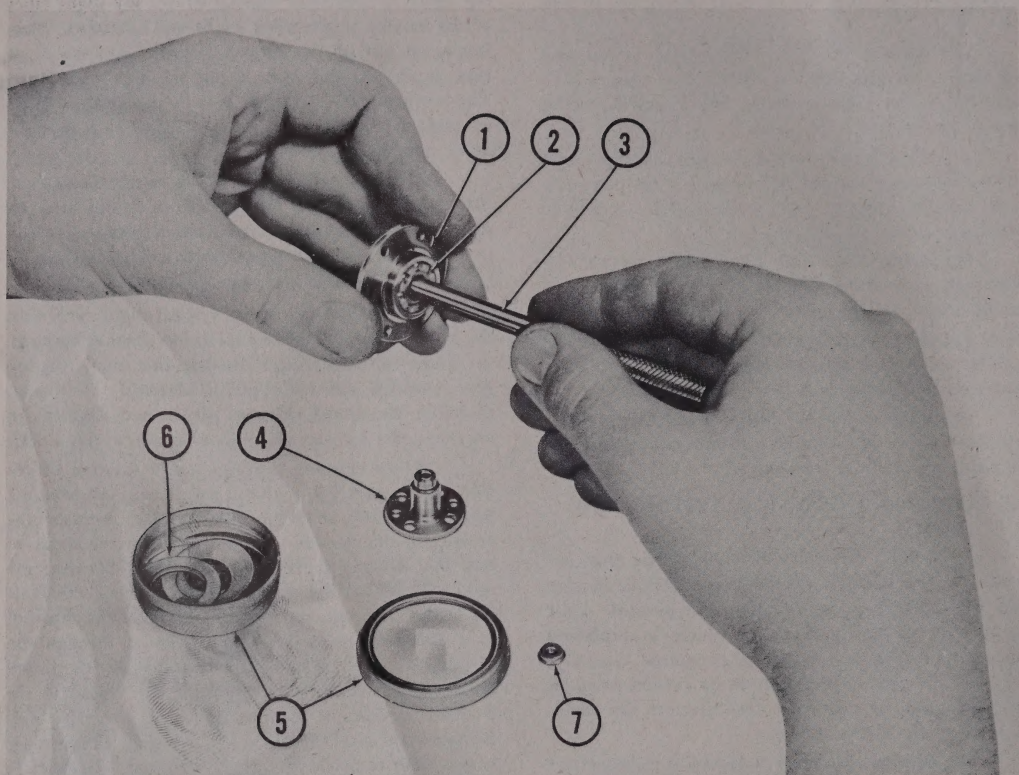


Figure 184 — Checking Bearings for Fit

Index No.	Nomenclature
1	Socket
2	Bearing
3	Pin
4	Gudgeon Pin

Index No.	Nomenclature
5	Covered Container
6	Shims
7	Locking Plug

CAUTION

Use only filtered compressed air. Do not spin the bearing with the compressed air, as this may cause damage.

(f) Self-aligning bearings may be twisted out of alignment by rotating the outer race, and the inside portion of the outer race may then be examined under a glass for small indentations caused by sharp blows. Bearings whose races are not clean and free from indentations must be discarded and replaced. Particular attention should be paid to that part of the race on which the bearings ride.

(3) BEARING LUBRICATION.—After bearings

have been properly fitted, cleaned, and inspected to make sure that they are suitable for replacement in the gyro, they must be carefully oiled and replaced in their covered containers. Use bombsight light oil (Army Air Force Specification No. 3582-A) on all bearings except the rotor bearings, which require heavy bombsight oil (Specification No. VV-0-581). Place the side which first enters the bearing bore down in the covered container.

(a) Use only *one* drop of oil for each row of bearing balls. In the case of double row ball bearings, one drop must be applied to each row of balls; and in single row bearings, only one drop need be applied.

(b) Apply oil with a wire or a dropper to be sure that only one drop reaches the bearing (figure 187). *Do not touch bearing with wire.* The end of the wire should be covered with solder to protect the bearing against scratches.

CAUTION

Over-lubrication of bearings will set up additional frictional forces in the bearings, which will cause unsatisfactory operation. Note that each bearing is lubricated immediately after cleaning and before placing in the covered containers. They must not be lubricated again as they are inserted in the gyro in re-assembly.

(4) WIRES AND FLEX LEADS.

(a) Inspect all flex leads for broken strands which may be sticking through the insulation. Connect an ohmmeter to each end of each flex lead and flex the lead to make sure there are no breaks which cause fluctuation of the indicator.

(b) Discard all faulty leads; replace with new ones.

(c) Examine wires removed from the cardan for worn spots on the insulation, breaks, damaged lugs, or other damage. Check these leads also with an ohmmeter to make sure there are no breaks beneath the insulation.

(d) Examine the wiring harness attached to the AN receptacle very carefully for breaks in the insulation, worn spots, and poor solder joints at the AN pins and lugs. It is well to check wires in the wiring harness with an ohmmeter for breaks even though the wire will be checked later for continuity in making connections to the terminal blocks.

(5) POTENTIOMETERS.

(a) Examine carefully all wires leading to, and a part of, both the single and triple potentiometer for breaks, worn spots, damaged insulation, and loose solder connections at the lugs or the potentiometers and contact assemblies. Examine each potentiometer assembly carefully for cracks in the block in which the potentiometers are cemented. Cracked or damaged parts should be replaced.

(b) Examine the potentiometer winding carefully for wear as indicated by excessive flat spots where the wiper travels, or for indentations of any kind on the surface. If either of these conditions are observed, the potentiometer and the block in which it is cemented should be replaced or thoroughly checked for satisfactory operation. Check each potentiometer winding with an ohmmeter for proper resistance. Correct resistance

values and permissible tolerances are given in the table of resistance values, figure 142A. Potentiometers are designated R1, R2, R3, and R4 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the potentiometer. In the final test after assembly, the potentiometer will be checked for cleanliness and for shorted turns.

(c) Examine the center contact assembly connections on the triple potentiometer carefully to make sure that they are not damaged. Adjustment of these assemblies will be covered in the final test of the assembled unit. (See this section, paragraph 2, e, (28).)

(d) Check wiper blades carefully. Replace bent blades, or those with worn contacts.

(6) GYRO HOUSING AND COVERS.

(a) Inspect gyro housing and covers for damage. Replace any damaged parts.

(b) Clean case and covers thoroughly, using a clean cloth moistened with carbon tetrachloride (U. S. Army Specification No. 4-503-110B). Blow out any loose dirt with compressed air. *Do not* blow out dirt in the same room where gyro is overhauled.

(7) ERECTING BAILS. (See figure 188.)

(a) Inspect the bails for any exterior damage, nicks, or scratches which might hinder their operation. Any damaged bail must be replaced.

(b) Examine bail corks carefully to make sure that they have not become chipped. If they are damaged, the entire bail assembly should be replaced unless

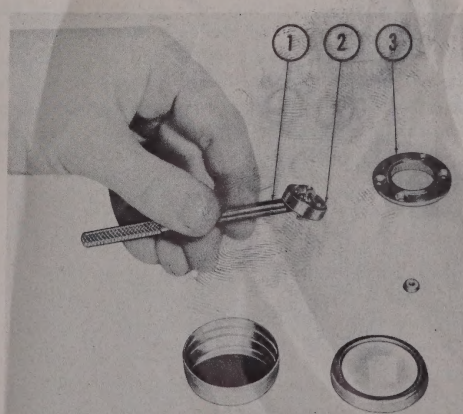


Figure 185 — Self-Aligning Bearing With Race Tipped Out of Line

Index No.	Nomenclature
1	Pin
2	Bearing
3	Socket

the special equipment required to face off new corks after insertion is available. Only in case of emergency should these corks be replaced with corks salvaged from another unit.

(c) Each bail is a balanced assembly, having been balanced in a special balancing machine at the factory. Any replacement or repaired bail will also be balanced, having the proper weights applied under the balancing screws on each side. *These balancing screws and weights must not be removed from the bail.* Unbalance of the bail assembly will show up in the test for bail fall, outlined in this section, paragraph 2, e, (31), and compensation may be made at that time. Whenever a complete bail assembly is replaced, the weight of the replacement bail may not be exactly the same as the one removed. In the final balancing operation, in re-assembly, compensation for this change of weight will be made.

(d) Check the clearance between the bail corks and the roller against which the bail operates, by slipping the erecting cut-out roller gear (13, figure 173), the upper erecting roller (11) and the two snap rings (12 and 10) on the spindle of the erecting gear frame assembly (17); holding the frame assembly in one hand, move the roller which operates in the particular bail being checked from one end of the bail to the other. This may also be done while the erecting rollers are on the rotor. Check the clearance between the roller and the bail corks with a thickness gage (figure 189). This clearance should be .015 inch to .022 inch. If more clearance than this is noted, the bail corks may be removed, and a very thin piece of paper placed between each bail cork and the bail. Replace the bail corks; lock them in place with the bail cork retaining plate and fourteen 2-56x3/16-inch flathead screws. Be sure to hold the cork back firmly against the paper shim as the retaining plate is tightened into place. After re-

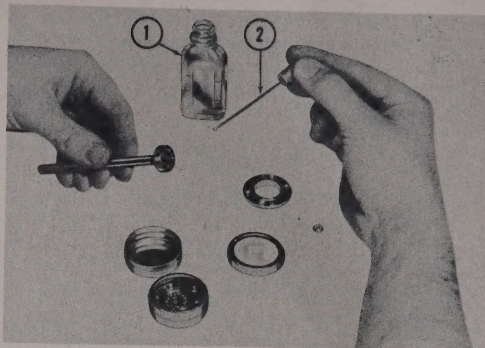


Figure 187 — Lubricating Bearings

Index No.	Nomenclature
1	Oil
2	Wire

placing the corks, again check for clearance between the roller and the bail corks. If clearance between cork and roller is then less than the minimum allowable clearance, it is necessary to face off the corks with special grinding equipment. If such equipment is not available, the bail assembly must be replaced.

(8) BAIL BUSHINGS AND GUDGEON PINS. (See figures 166 and 171.)

(a) The four gudgeon pins which fit into the gyro housing have been, for convenience, numbered in a clockwise direction, starting with No. 1 over the AN receptacle. In removal, these pins were scribed on top so that they could be replaced in exactly the same position.

(b) The two cardan gudgeon pins which fit into the locked and free bearings of the rotor case are usually plainly marked with an "F" or "R" stamped on each gudgeon pin. The "F" gudgeon pin (15, figure 171) goes in the locked bearing and is located on the side of the erecting cut-out magnet. The "R" gudgeon pin (3) is for the free bearing and is on the opposite side of the cardan.

(c) Inspect all gudgeon pins for burrs. Carefully check the fit of each gudgeon pin in its proper location in the housing or cardan. If a new gudgeon pin is required, it must be carefully fitted to the exact position in which it is to be used, and also to the bearing with which it is to be used. All gudgeon pins are a select fit; therefore, several gudgeon pins must be available so that one which fits properly may be selected.

(d) In case a pin of the correct fit is not available, a gudgeon pin which is slightly large may be

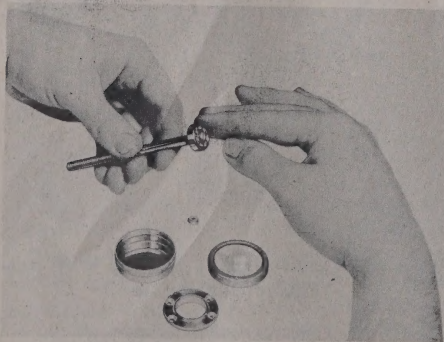


Figure 186 — Testing Bearings by Feel

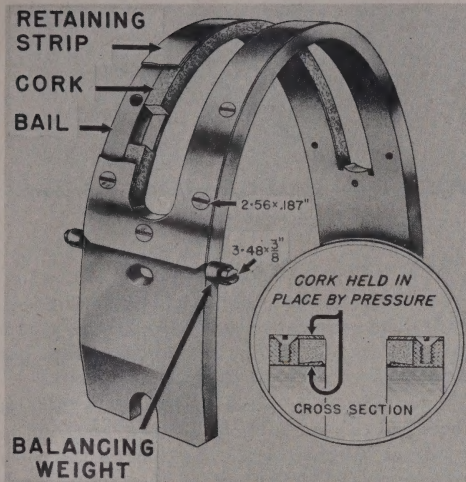


Figure 188 — Bail Assembly

polished down with crocus cloth to fit the cardan, housing, or bearing with which it is to be used. Always use a very fine polishing cloth in the final fitting operation. These operations with crocus cloth or polishing cloth should be done with the gudgeon pin chucked in a small lathe, so that an equal amount of material is removed all the way around the pin.

(e) If it is necessary to replace one of the rotor case gudgeon pins, the balance of the gyro may be affected; consequently, particular care should be used in the final balancing operation in reassembly. If the locked bearing gudgeon pin is replaced, the alignment of the rotor spindle may be affected; consequently, particular care should be used in realigning this spindle, as well as in balancing.

(f) Keep a fine film of light oil on all gudgeon pins at all times.

(g) Each of the four bail bushings is fitted to the gudgeon pin with which it is used. Check the fit of each bail bushing on the gudgeon pin with which it is to be used. Push the bushing back up against the shoulder, turning it to see if any burrs on the shoulder restrict its free motion. If a bail bushing must be replaced, fit it carefully to the gudgeon pin with which it is to be used. This is also a select fit, but the gudgeon pin may be polished down, if necessary, until the proper fit is obtained. Bail bushings must fit loosely on the gudgeon pin. Examine the inside bore of the bail bushings; if roughness is observed, chuck the bail bushings in a drill press, or a small lathe, and use polishing paper on the inside to smooth up the rough

spots. Some of the bail bushings used are made of cast iron; others are oilite bushings. If the bushing seems sticky on the gudgeon pin, it is probably an oilite bushing. Wash it in carbon tetrachloride to relieve the stickiness, and clean out the bore with an ordinary pipe cleaner. A light film of oil should be placed on the cast iron bail bushings to prevent rust.

(9) ROTOR CASE BEARING SOCKETS.

(a) Check rotor case bearing sockets to make sure that they are free from scratches or nicks of any kind which might prevent the locked bearing socket from seating firmly against the rotor case, or which might prevent the free motion of the free bearing in its socket. Polish out nicks or scratches with a fine polishing cloth, or if this will destroy the fit of the bearing in the socket, it must be replaced.

(b) If either socket is replaced, make sure that it fits properly in the rotor case and also that the bearing used with it fits properly. (Locked bearing snug fit, free bearing sliding fit.) If the locked bearing socket is replaced, shims previously used may not be correct to lock the bearing properly in place, and it will be necessary to use extreme care in making this adjustment in re-assembly.

(10) COUNTERBALANCE GUIDE CHANNELS.

(a) Wash off the counterbalance guide channel thoroughly with carbon tetrachloride (U. S. Army Specification No. 4-503-110B) to remove all dirt and oil which may have collected in the channel and polish with clean lint-free cloth.



Figure 189 — Checking Clearance Between Roller and Bail

(b) Carefully inspect the guide channel for any burrs or nicks which might prevent the free movement of the roller in the channel. Any nicks observed should be polished off with a fine polishing cloth; then the guide roller should be passed through the channel to make sure that it is free to move without friction (figure 190).

(c) If for any reason the counterbalance guide channel is replaced, new bearings must be carefully fitted to the new channel. If the channel is replaced, it must be measured carefully with a micrometer to make sure that the clearance between the roller and the guide channel is not less than .00075 inch or more than .0015 inch.

(d) The counterbalance guide channel is a balanced assembly carefully balanced on a balancing machine at the factory. Therefore, the balancing weight should not be disturbed unless absolutely necessary, except in the final balancing operation to balance the counterbalance guide channel and top bail assembly.

(11) GUIDE ROLLER ASSEMBLIES.

(See figure 177.)

(a) Make sure that the guide roller bearing (5) fits properly in the guide roller (4). The bearing should fit tightly in the roller, but not so tightly that it cannot be pushed into place by hand. The bearing should fit snugly on the screw stud (6).

(b) Wash the guide roller in carbon tetrachloride (U. S. Army Specification No. 4-503-110B); polish off the surface where it has come in contact with the aluminum guide channel, using a very fine polishing cloth. After cleaning and polishing, apply a thin film of oil to the guide roller to prevent rusting. If for any reason the guide roller cap (3) has been replaced, make sure that it fits snugly, but not tightly, in the rotor case.

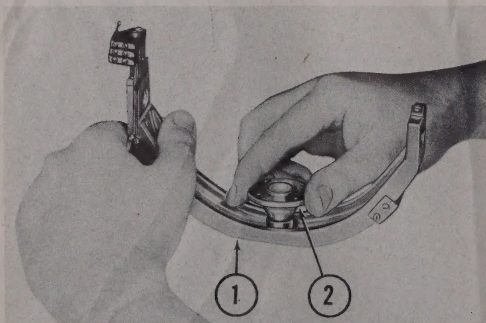


Figure 190 — Testing Fit of Guide Roller in Channel

Index No.	Nomenclature
1	Counterbalance Guide Channel
2	Guide Channel Roller Assembly

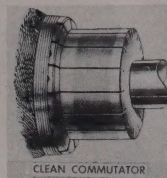


Figure 191 — Good Commutator, a Smooth Bronze Color

(12) WIPER BLADE ASSEMBLIES.

(a) The contacts of the wiper blades will groove slightly from wear as the gyro is used. This groove should be very slight; if it is much more than just noticeable, the wiper blade should be replaced.

(b) The single wiper blade may be replaced without replacing the wiper blade block. However, in the case of the triple wiper, the leads to the wiper blades are cemented into the block; if any of the wiper blades must be replaced, the entire assembly should be replaced.

(c) Examine wiper blocks carefully for cracks, replacing any which do not seem satisfactory.

(13) LEVEL VIAL ASSEMBLIES.

(See figure 175.)

(a) At room temperature of approximately 75° F., level bubble should extend over approximately two of the degree spaces on the vial. If the bubble does not conform to this specification very closely, the level vial should be replaced.

(b) Clean level vials thoroughly before re-assembly.

(14) ERECTING CUT-OUT ASSEMBLY.

(See figure 173.)

(a) The erecting cut-out gears, including the pinion, which is part of the locking nut on the rotor shaft, have been carefully fitted and therefore are a matched set of gears. Examine all gears carefully for wear or nicks which might impair their operation. If any one gear must be replaced, all gears should be replaced with a matching set of gears which have been properly fitted together. A frame and spindle assembly is, of course, a part of the matched set and should be replaced along with the matching set of gears. Only in case of emergency should individual parts be replaced. Check operation carefully in re-assembly.

(b) Check the resistance of the erecting cut-out magnet with an ohmmeter. Current resistance value and permissible tolerance are given in the table of resistance values, figure 142A. This magnet coil is designated as F2 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the coil.

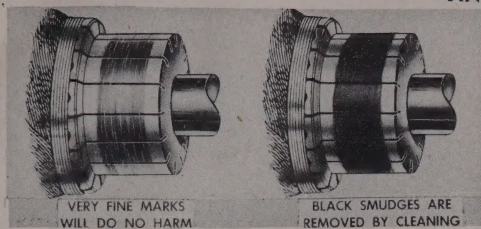


Figure 192 — Dirty Commutator, Easily Cleaned

Note

The small lug on the erecting cut-out magnet to which is fastened the fine wire emerging from the magnet winding may be twisted off very easily. Therefore, great care should be used in tightening the terminal screw to make sure that in tightening this lug it does not turn and break the wire to which it is connected.

(c) Inspect the gear-actuating arms on the armature to make sure that they are not bent out of shape. Be sure that the anti-stick pin is in place.

(15) ROTOR AND HOUSING ASSEMBLY.

(See figure 179.)

(a) Examine the rotor case (2 and 8) carefully to make sure that it is not damaged in any way. The two halves of the rotor case are a matched pair; if either half is damaged, both halves must be discarded.

(b) **BRUSH HOLDERS AND BRUSHES.**—Examine brush holders and insulating tubes carefully to see if they have become damaged. Brush holders and insulating tubes will not ordinarily be removed in disassembly unless they require replacement. Whenever a new brush holder, insulating tube, or brush is installed, brushes must be fitted to the commutator, as outlined in this section, paragraph 2, e, (7). Measure the length of the brush; if the brush length is less than $\frac{1}{2}$ inch, the brush should be replaced. Clean brushes carefully by wiping them with a clean, dry cloth. To wipe out the interior of the brush holder, use a piece of cloth wrapped around a match stick, or piece of stiff wire. Brush holders only may be washed in carbon tetrachloride (U. S. Army Specification No. 4-503-110B). If the brush spring or brush lead wire is damaged, or the adjusting plug has damaged threads, replace the brush assembly.

(c) **ROTOR BEARINGS.**—Rotor bearings should not have been removed unless a dynamic balancing machine is available for re-balancing the armature and rotor assembly. If rotor bearings are not removed, the armature and rotor assembly cannot be disassembled. Rotor bearings should be cleaned, inspected, and lubricated in the same manner as outlined for other bearings in this section, paragraph 2, d, (1). The rotor

bearing bushings are part of the rotor case assembly and must not be removed.

(d) **ROTOR.**—No maintenance is required on the rotor itself, but a careful examination should be made to be sure that it has not rusted.

Note

Do not remove balance screws from rotor except in the process of dynamic balancing. Do not handle the rotor except with a soft cloth, or when gloves are worn. Handling the rotor with bare hands will cause it to rust rapidly. A light film of oil should be kept on the rotor at all times, applied with a soft cloth moistened with light oil.

(e) ARMATURE AND COMMUTATOR ASSEMBLY.

1. **CLEANING.**—The armature may be cleaned, if necessary, with a clean cloth slightly dampened with carbon tetrachloride (U. S. Army Specification No. 4-503-110B).

2. **OPEN CIRCUIT.**—An open-circuited armature is usually easily detected, since this condition causes badly burned commutator bars. Some bars badly burned, and others fairly clean, indicate an open-circuited armature. The bars connected to the open coils in the armature soon burn, since every time they pass under the brushes they interrupt a flow of current so that arcing occurs. The "open" will usually be found at the commutator bar. An open-circuited armature should be replaced.

3. **GROUND ARMATURE.**—Check the armature for ground by using an ohmmeter to check between the armature shaft and the commutator bars. If the ohmmeter needle moves, a ground is present and the armature should be replaced.

4. **SHORTED ARMATURE.**—A short-circuited armature may be detected on a growler. The growler is a strong electromagnet connected to a source of alternating current. When a shorted armature is placed on the growler and a hacksaw blade held above the shorted coils in the armature, the blade will be alternately attracted to and repelled from the armature, causing the blade to buzz against the armature. Before

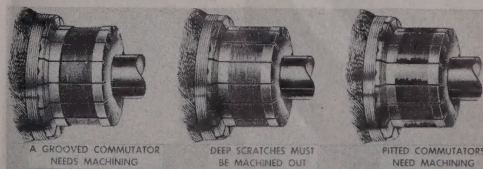


Figure 193 — Worn, Scored, or Burned Commutator

discarding an armature which this test shows to be short-circuited, inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts adjacent bars.

a. If the commutator is brown or bronze in color and the slots between the segments are deep and clean, the commutator does not require cleaning. (See figure 191.)

b. If the commutator is blackened or smudged with oil or carbon, it should be cleaned. (See figures 192 and 193.) A good test is to rub the commutator with your finger. If you are able to rub off any carbon or stain, the commutator needs cleaning. To clean the commutator, wipe with a clean cloth moistened only slightly with carbon tetrachloride (U. S. Army Specification No. 4-503-110B). If this does not remove the discoloration, place the commutator in a lathe, and, using a fine sandpaper or polishing cloth, polish off the commutator bars to remove the discoloration. If bearings have not been removed, they must be wrapped and taped carefully to prevent abrasives from falling into the bearings. If the slots between the commutator bars have become filled up with dirt or carbon particles, they should be cleaned out with an orange stick, or similar sharp piece of wood. *Do not use any metal for this purpose.* If the dirt and carbon cannot be removed with this method, mica should be undercut, as shown in figure 195.

c. If the commutator is badly scored or pitted, or if the brushes have worn a groove in the surface of the commutator, the commutator must be turned down in a lathe, as shown in figure 194. In turning down the commutator, make no cut that is deeper than necessary. After turning down the commutator, the mica between the commutator bars must be undercut, as shown in figure 195. Undercut mica only about 1/64 of an inch.

(f) FIELD COIL.—Examine the field coils care-

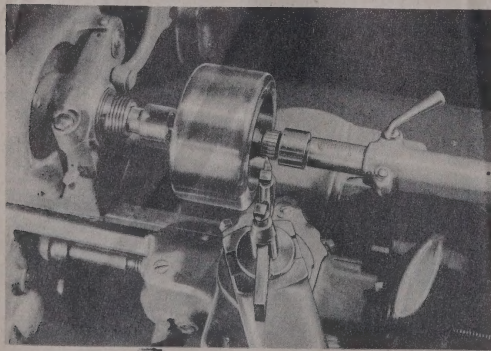


Figure 194—Turning Down Commutator in Lathe

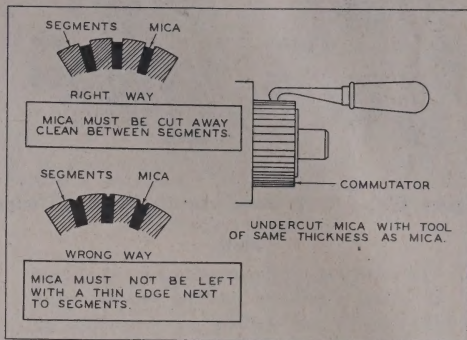


Figure 195—Undercutting Mica on Commutator

fully to make sure that they have not been burned or overheated to an extent which might hinder their operation. Using an ohmmeter, test the resistance of each field coil. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. The field coil resistance is designated FI in the table. If resistance is not within the prescribed limits replace the coil.

e. REASSEMBLY.

NOTE

Make sure that any parts not in covered containers have not collected dust or dirt before re-assembling.

(1) REASSEMBLE TERMINAL BLOCKS AND WIRING HARNESS TO HOUSING.

(a) (See figure 183.) Using twelve 4-40x7/16-inch, fillister-head screws, attach terminal block brackets (8) to bottom of housing.

(b) Secure the two-terminal block assembly (9), with the 2000-ohm resistor (7) attached, to the terminal block brackets on the identification plate side using two 4-40x3/8-inch, fillister-head screws.

(c) Secure the four-terminal block (10) to the terminal block brackets on the side opposite the AN receptacle (3) with two 4-40x3/8-inch, fillister-head screws.

(d) Secure the three-terminal block (11) to the terminal block brackets on the side opposite the identification plate with two 4-40x3/8-inch, fillister-head screws.

(e) Place fiber gasket against housing; install AN receptacle adapter (1) over gasket using internal tooth lock washers and four 4-40x5/16-inch, fillister-head screws. Use care not to damage gasket in installation.

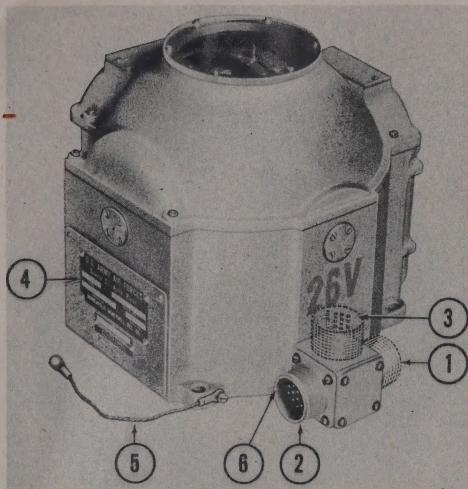


Figure 196 — AN Receptacle Position

Index No.	Nomenclature
1	AN Receptacle Position No. 1
2	AN Receptacle Position No. 2
3	AN Receptacle Position No. 3
4	Identification Plate
5	Ground Lead
6	Key

NOTE

The correct position for the outlet of the adapter is indicated by the order number on the identification plate. (See figure 196.)

Type Number	AN Receptacle Position
G 1021B1 or G 1021B301	1
G 1021B2	3
G 1021B3 or G 1021B303	2
G 1021B4	3

(f) (See figure 183.) Insert AN receptacle wiring harness through a fiber gasket; insert wire harness into adapter (1) and through the hole into the housing. Use care not to damage the gasket, or to loosen the soldered connections on the AN receptacle.

(g) Secure AN receptacle (3) to adapter (1) with internal tooth lock washer and four 4-40x1/4-inch, fillister-head screws, making sure key (6, figure 196) is on side next to housing.

(h) Place fiber gasket over end of adapter; install cover plate (2, figure 183) with internal tooth lock washers and four 4-40x1/4-inch, fillister-head screws.

(i) Route wire harness around the inside of housing clockwise from the AN receptacle; install the three large, lead wire, hold-down clamps (4, 5

and 6) which hold wiring harness to housing, using three 4-40x1/4-inch fillister-head screws. Tighten down on the wiring harness only the clamp (4) closest to the AN receptacle (3).

(j) Connect the red wire from the wiring harness to one terminal (12) of the 2000-ohm resistor. Connect the yellow jumper lead, which is not part of the wiring harness, to the other terminal (13) of the 2000-ohm resistor. Place this yellow lead and the wiring harness under the second clamp (5), proceeding in a clockwise direction from the AN receptacle. Tighten down this second clamp.

(k) Continue the two long wires on around the housing under the third clamp (6) but do not tighten this clamp until the jumper wire and the wires from the single (elevator) potentiometer are in place.

(2) INSTALL WIPER AND TERMINAL BLOCKS ON CARDAN. (See figure 181.)

(a) Connect the wires to the three-terminal block (6) which mounts on the under side of the cardan, using three 3-48x1/4-inch binding head screws.

1. The 8-inch lead wire (4) and a 4-inch flex lead connect to the left-hand terminal screw, with the lugs extending away from the mechanic.

2. The 4-inch lead wire (1) and a 4-inch flex lead connect to the center terminal screw, with the lugs extending away from the mechanic.

3. The 6 1/2-inch lead wire (5) and a 4-inch flex lead connect to the right-hand terminal, with the lugs extending away from the mechanic.

(b) Install this three-terminal block, with wires attached, to the under side of the cardan with flat washers and two 3-48x3/8-inch, fillister-head screws. Wire lugs must extend toward the small end of the cardan, but must not touch cardan.

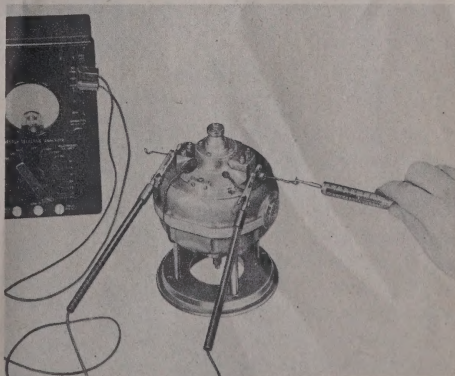


Figure 197 — Testing for Brush Tension

Section IV
Paragraph 2

RESTRICTED
AN 11-60AA-2

(c) Install small two-terminal block (7) on the top of the cardan with two 3-48x5/16-inch, fillister-head screws. Bring the 8-inch wire (4) from the three-terminal block on the bottom of the cardan up and across the cardan; connect it to the nearest terminal of the two-terminal block with a 3-48x1/4-inch binding head screw. Bring the 6 1/2-inch wire (5) up on the same side as the two-terminal block; connect it to the remaining terminal of this block with a 3-48x1/4-inch binding head screw.

(d) Form these wires along the top of the cardan, as shown in figure 181. Secure them to the cardan with the two-wire block clips (8) and two 3-48x5/16-inch, fillister-head screws.

(e) Install cardan wiper block mounting pedestal (3), using two 3-48x5/16-inch, fillister-head screws. Be careful to see that the recessed corner fits over the 8-inch motor lead wire (4), as shown, and does not damage the insulation. After securing pedestal to cardan, press the 8-inch lead wire (4) in against the pedestal, and fasten it and the 4-inch wiper lead wire (1) to the side of the cardan with two clamps and a 3-48x3/16-inch, fillister-head screw. Fasten the 6 1/2-inch lead wire to the other side with a clamp and a 3-48x3/16-inch, fillister-head screw.

(f) Secure single (elevator) wiper mounting block (2) to pedestal, using two 3-48x7/16-inch, fillister-head screws with flat washers. Fasten the wiper blade assembly to the block (2) with one 3-48x1/4-inch

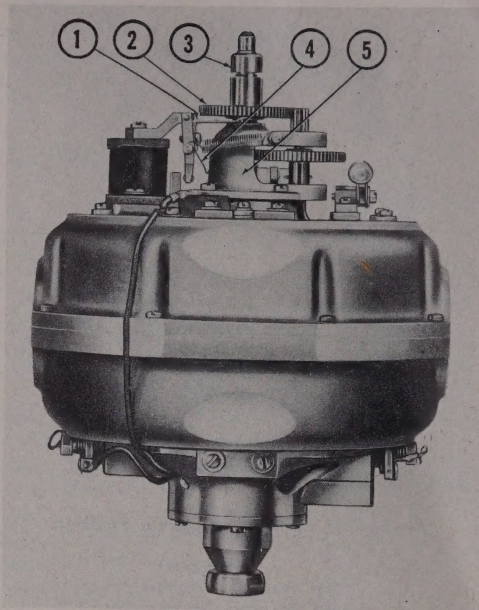


Figure 199 — Adjustment of Erecting Cutout Mechanism

Index No.	Nomenclature
1.	Actuating Arm
2.	Roller Gear
3.	Top Roller
4.	Stop
5.	Frame

binding head screw; place the lug of the 4-inch lead wire (1) under the second 3-48x1/4-inch binding head screw, which also fastens the wiper to the block.

(3) INSTALL TRIPLE POT WIPER ASSEMBLY ON COUNTERBALANCE GUIDE CHANNEL. (See figure 182.)

(a) Using two 3-48x3/8-inch, fillister-head screws, secure the triple wiper block mounting pedestal (3) to the guide channel, making sure that the large counterbored end of the threaded hole for the erecting bail retaining screw is on the outside.

(b) Install the triple wiper block assembly (2) on top of the pedestal, using two 3-48x7/16-inch, fillister-head screws with flat washers.

(c) Carry the single flex lead (6) extending from one side down that side of the pedestal, securing it with a clip (4) under the fillister-head screw which attaches the pedestal to the guide channel on that side. Carry the lead on down the side of the guide channel, and secure it to the side of the channel with a clip (5)

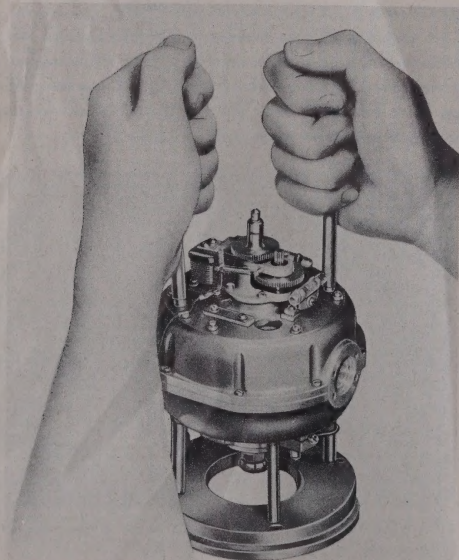


Figure 198 — Reseating Rotor Bearings

and a 3-48x3/16-inch, fillister-head screw. Carry the two leads (7 and 8) from the opposite side of the triple pot wiper block down the other side of the guide channel, and secure with a clip (1) and another 3-48x3/16-inch, fillister-head screw. Cement these wires to the counterbalance guide channel at the point (9) where the pedestal meets the channel.

CAUTION

Be sure that tape is wrapped around the flex leads where they go through the clips (1, 4, and 5).

(4) ASSEMBLE LOWER ROTOR CASE ASSEMBLY. (See figure 179.)

(a) Insert each field coil (7) over a pole piece (6), taking care to match up scribe marks made in disassembly. Fasten the pole pieces to the field ring (4) with two 6-32x3/8-inch, flathead screws (5). Before tightening the screws (5) and staking them in place, make sure the pole pieces are lined up to clear the armature properly.

Note

If no jig for lining up the pole pieces is available, a substitute method, using a discarded armature with lower rotor bearings in place, may be used. First, proceed with step (b) following. Then wrap paper around the discarded armature until it will just fit snugly between the pole pieces and insert the lower rotor bearing into place in the bore of the case. This will bring the pole pieces into proper alignment with the armature axis, and the paper wrapped around the armature will assure clearance between the armature itself and the pole pieces at all points. Then tighten securely the flathead screws holding the pole pieces, and stake them into place.

CAUTION

In disassembly, the field ring was scribed on the side next to the lower bearing oil hole. This is the side on which the field coil having the longest lead must be reinstalled.

(b) Insert field assembly into lower rotor case (8), taking care to line up the scribe mark on the side of the oil hole, and being careful to insert both lead wires from the coil on the side next to the oil hole through the small hole closest to the oil hole. Lead wires from the coil on the opposite side go directly out through the two holes closest to each lead wire. Fasten the field assembly securely into the lower half of the rotor case with two 4-40x11/16-inch, fillister-head screws (11).

(c) Slip a brush holder insulating tube (10) over each brush holder (9); press the brush holder

assemblies into the lower rotor case with an arbor press. Take care that inner end of holders enter only far enough to line up with the bore into which the lower rotor ball-bearing socket is pressed. Be sure that the ears of the brush holders are away from the rotor case and that identifying marks line up.

(5) ASSEMBLE ROTOR ASSEMBLY.

(See figure 180.)

CAUTION

If the rotor assembly has been disassembled, it must be dynamically balanced after assembly into the rotor case. If the assembly was *not* disassembled and the bearing retaining nuts were not loosened nor the dynamic balance disturbed in any other way, this step and dynamic balancing step (8) may be omitted. *However*, if dynamic balancing equipment is available, *always* dynamic balance rotor, as outlined in step (8).

Note

Rotor must be handled only with gloves, or a clean cloth, to avoid causing rusting of its polished surface.

(a) Insert armature shaft into rotor (4), taking care to line up scribe marks so that the same holes line up as they did in disassembly. Bolt rotor rigidly to armature, using six 5-40x5/16-inch, fillister-head screws (3).

(b) Install the large rotor bearing (6) on the lower end of the rotor shaft next to the commutator and the small bearing (2) on the top end of the shaft. Both bearings must slide onto the shaft snugly, but should not be so tight that they cannot be pushed into place with the fingers. Screw the lower lock nut (7) on the lower end of the shaft and the upper lock nut assembly (1), with the erecting gear pinion, onto the upper end of the shaft. Pull both nuts up tightly to seat bearings in place.

CAUTION

Do not lubricate bearings. Bearings were lubricated when cleaned, and no additional lubrication is necessary.

(6) ASSEMBLE ROTOR INTO ROTOR CASE.

(a) Moisten a clean, lint-free cloth with light oil, and wipe over all of the polished surface of the rotor. Then use a clean, dry cloth to wipe off the oil, leaving a fine film of oil which will prevent this polished steel surface from rusting after assembly.

(b) Holding the rotor with a clean cloth, or wearing gloves, insert the lower bearing into the bottom half of the rotor case (8, figure 179.) If shims were found below the lower bearing when the unit was

disassembled, be sure the same shims are in place. The outer bearing race must be lined up perfectly so that it will slip easily into the case.

(c) Place the lower half of the case (8) on the rotor case stand, taking care that the supporting pins on the stand are properly inserted into the holes giving access to the rotor-balancing screws.

(d) Place the upper half of the rotor case (2) over the rotor, after making sure that the outer bearing race of the upper bearing is properly lined up. Slide the upper half of the rotor case into place.

CAUTION

Do not force rotor bearings into place. These bearings have been carefully fitted; when the race is properly in line, they will slip easily into place.

(e) Insert the eight 4-40x7/16-inch, fillister-head screws (1) which hold the two halves of the rotor case together. Be sure that these screws are pulled up tight and that the case halves line up so bearing sockets may be inserted against a flat surface.

(f) Bring up the two long motor leads through the slot in the flanges of the rotor case, and, drawing them tight, secure them to the top of the rotor case by means of the two lead small wire clamps (8, *figure 175*), held to the case by two 3-48x3/16-inch, fillister-head screws. Install the small fiber terminal block on top of the rotor case and connect the lug on the one motor lead to it. Connect the other lead to the ground lead terminal.

(7) INSTALL MOTOR BRUSHES.

(a) Insert the brush scribed with one mark (*figure 176*) in the brush holder, also scribed with only one mark, making sure that the marked side of the brush (1) is away from the case. Install the brush scribed with two marks in the brush holder, also scribed with two marks. Again, the scribe marks should be away from the case.

(b) If new brushes are being installed, make certain that the brush is inserted so that the curve on the end of the brush corresponds to the curve of the commutator on the armature. After inserting the brushes, screw the brush holder plug (6) in part way. If new brushes have been fitted, the motor should then be run for a few minutes. Then the brushes must be removed to observe how the brush is contacting the commutator. Examine the contacting surface for shiny spots, indicating where the commutator came in contact with the end of the brush. These high spots should be scraped away, and the brush tested again and scraped until good contact is attained over the entire end surface of the brush.

(c) Adjust brushes to proper tension (*figure 197*), using a spring scale or gram gage clipped to the terminal lug. Pull straight out until contact between

the brush and commutator is broken, noting pull recorded on spring scale at this point. Adjust the brush holder plug in or out until a tension of 3 to 3½ ounces is recorded on the scale. The point at which contact is broken may be accurately determined by connecting an ohmmeter across the brushes so that the indicating needle will fall when contact is broken.

(d) After the brush tension of both brushes has been properly adjusted, attach a field coil lead to each brush holder terminal, using two 3-46x3/16-inch binding head screws and plain washers. Connect lugs of the brush leads to the remaining terminal on each brush holder, again using 3-46x3/16-inch binding head screws with plain washers.

(e) Make sure that the brush lead lugs are bent out straight from the brush holder and that brush leads are formed out straight from the brush holder plugs for at least 3/16 of an inch, so that as the brush wears, the brush lead will not prevent the brush from moving in against the commutator.

CAUTION

Form the brush lead so that it does not touch either the rotor case or the cardan, even when the gyro is in an extreme position. (*See figure 158.*) Apply a thin layer of insulating varnish to a small area of the rotor case immediately below each brush so that no shorts will occur if brush lead should come in contact with the case. A short at this point will burn out the flex lead.

(8) DYNAMICALLY BALANCE ROTOR IN CASE.—Dynamically balance rotor with a dynamic balancing machine if such a machine is available, or if bearings have been removed from rotor shaft. (*See figure 156.*) Dynamic unbalance of the rotor must not exceed 200 micro inches at operating speed of 6500 to 8000 rpm.

(9) INSTALL ERECTING CUT-OUT MECHANISM. (*See figure 173.*)

(a) Press the two small ball bearings (16) into place in the erecting cut-out gear frame assembly (17). Be sure to insert the small spacing washer (21) under the lower bearing.

(b) Place any shims removed from under the erecting cut-out frame assembly in place on top of the case; put erecting cut-out frame assembly in place, and secure with four 4-40x5/16-inch, fillister-head screws (15).

(c) (*See figure 198.*) Check for end play of rotor in rotor case. This is done by first pushing the rotor down toward the bottom of the case as far as it will go, using two brass pins through the two holes provided for access to the rotor balance screws. Use one pin on each side; press on both at the same time. Then pick up the rotor case carefully; turn it over slowly,

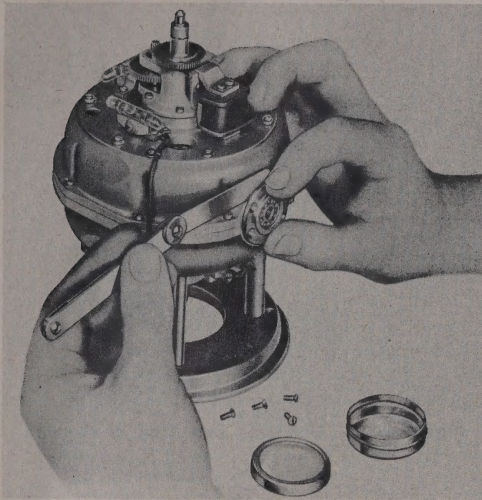


Figure 200 — Determining Shim Thickness for Locked Bearing

listening to see if the rotor shifts in the case. If the rotor does not shift, place it on the stand in the upside-down position. Again using the two brass pins through the holes provided for access to the balance screws, press the rotor toward the top of the case. If a slight shift of position is noted, end play is present. End play at this point is absolutely necessary, but may vary as much as .020 inch, and therefore measurement of end play is not necessary. If end play is not present, place as many shims as required under the erecting cut-out frame assembly. Replace the rotor and case assembly in the upright position on the stand, and reseal rotor.

(d) (See figure 173.) Insert the bronze intermediate gear (20) between the two arms of the cut-out gear frame assembly (17), being sure to insert also the spacer between this gear and the lower ball bearing, if such a spacer was found on the gyro being overhauled. Insert the intermediate pinion shaft (14) through the upper ball bearing and through the intermediate gear, taking care to line up the hole for the tapered pin (19). Both the hole in the gear and in the shaft are tapered, and the two large ends of these holes should be lined up together on one side. Insert the tapered pin in the large end of this hole, and tap into place with a pin punch and light hammer. Check to see that intermediate gear meshes properly with the rotor pinion and does not ride on the shoulder.

(e) Place one drop of light bombsight oil on erecting cut-out roller spindle; spread the oil evenly over the surface of the spindle.

(f) Place roller gear (13) over the spindle so that it meshes with the intermediate pinion; slide one of the snap rings (12) down over the spindle into the lower groove. Then slide the upper roller (11) over the spindle, and install the second snap ring (10) in the top groove on top of the upper roller. Clean the rollers thoroughly of all oil which may be on the outer surfaces.

(g) Place erecting cut-out magnet base (9) on top of housing over the holes opposite the bronze intermediate gear. Place the erecting cut-out magnet (8) on top of the base so that the terminal screw is on the same side as the small motor terminal block on top of the case (22).

(h) Assemble the armature bracket assembly, if it has been disassembled. This is done by inserting the hinge pin (4) through the armature assembly (3) and the bracket (2); flatten out end of pin so it will not work loose. Secure the gear actuating arm (5) to the armature, using two 2-56x3/16-inch, fillister-head screws (6).

(i) Place armature bracket assembly on top of erecting cut-out magnet (8); insert the two 4-40x1 1/4-inch, fillister-head screws (1) which secure the entire assembly to the rotor case (22). Tighten the screws down securely. Place the spring (18) in place between the two spring studs. Check carefully for any binding in the gears, particularly if any individual parts have been replaced.

(j) Check adjustment of erecting cut-out mechanism, as follows: (See figure 199.)

1. Check to see that the stop (4) on the actuating arm (1) rests against the frame (5).

2. Check to see that both fingers of the arm rest against the lower surface of the roller gear (2), and that they clear the shoulders of the frame on both sides.

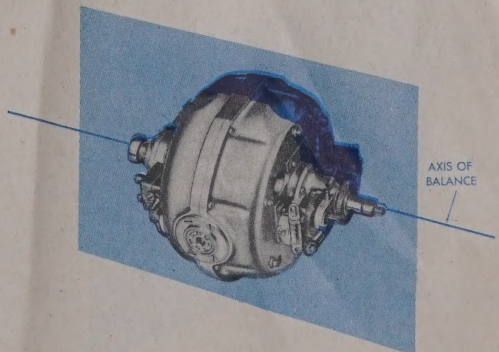


Figure 201 — Spin Balancing About Plane I

3. With the stop against the frame, make sure that the roller gear (2) is not lifting the top roller (3), but that at least $\frac{3}{4}$ of the length of the dogs between the gear and roller are engaged.

4. Holding the armature against the magnet base, check to see that top roller dogs do not engage dogs on the roller gear. Clearance between these dogs must be at least .002 inch minimum so that when snap ring wears, proper clearance will still be assured.

(10) INSTALL LEVEL VIAL ASSEMBLY.

(See figure 175.)

(a) Install one level vial bracket (1) on the side opposite the erecting cut-out magnet, and the other level vial bracket on the side opposite the spring on the erecting cut-out mechanism, using two 3-48x $\frac{1}{4}$ -inch, fillister-head screws (2) through each bracket. A balancing weight may be found in the spot where the bracket, opposite the magnet, attaches. In case such a weight is found, the level vial bracket may be installed, using the screws through this balancing weight.

(b) Insert a 4-40x $\frac{3}{8}$ -inch, fillister-head screw (7), with a plain washer (6), through the two parts of a level vial clamp (3), with a spacer washer (5) between the two parts, and attach to the outside of each level vial bracket.

(c) Insert a level vial (4) in each level vial clamp so that it is centered from end to end, and so that graduation lines are centered on top.

(d) Tighten screws in level vial clamps, with level vials in approximately the center position.

(11) INSTALL GUIDE CHANNEL ROLLER ASSEMBLY. (See figure 177.)

(a) Push the bearing (5) into place in the roller (4). This bearing should fit tightly in the roller, but not so tightly that it cannot be pressed in by hand.

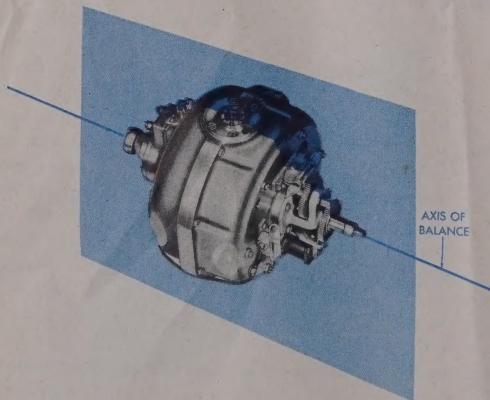


Figure 202 — Spin Balancing About Plane II

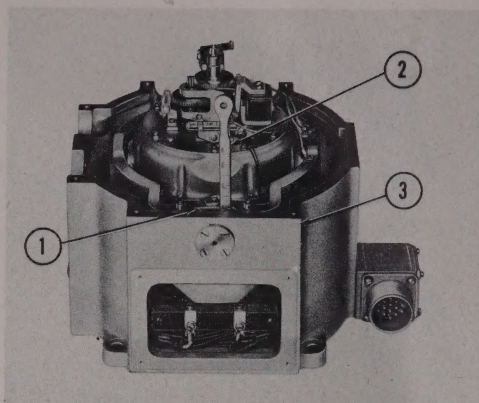


Figure 203 — Checking End Play of Cardan

Index No.	Nomenclature
1.	Cardan
2.	Housing
3.	Taper Gage

(b) Insert the guide roller screw stud (6) through the bearing. Insert the stud into the guide roller cap (3), making sure that the flange on the roller (4) is next to the roller cap. Place a flat washer (8) over the guide roller stud; secure in place with the stud nut (2), making sure that nut is pulled up tight.

(c) Turn the rotor case (1) over on the stand. Install the guide channel roller assembly in place on the under side of the rotor case, making sure that scribe marks on the edge of the cap line up with the mark on the bottom half of the rotor case. Fasten the guide channel roller assembly in place, using four 4-40x $\frac{3}{8}$ -inch, fillister-head screws (7).

(12) INSTALL ROTOR CASE BEARINGS AND SOCKET. (See figure 171.)

(a) The locked bearing (11), designated as the "F" bearing, is installed on the same side as the erecting cut-out magnet. The locked bearing socket (13) is easily identified because of the shoulder on the outside against which the outer race of the bearing rests.

(b) The free bearing (6), designated as the "R" bearing, is installed on the opposite side. The free bearing may be pushed all the way through the free bearing socket (5).

(c) Both the locked bearing (11) and the free bearing (6) have one side of the inner race beveled to fit the locking plugs (7 and 10) which lock the inner race of each bearing to its gudgeon pin.

(d) Remove the locked bearing (11) and socket (13) from the covered container into which they were

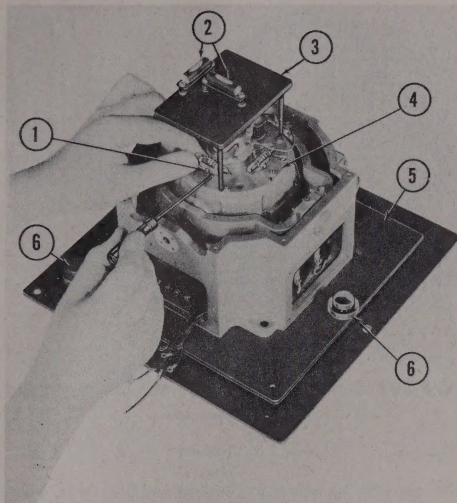


Figure 204 — Adjusting Level Vial

Index No.	Nomenclature
1.	Locking Screw
2.	Level Vials
3.	Master Level Gage
4.	Rotor Case
5.	Leveling Plate
6.	Leveling Screws

placed after washing and lubrication, making sure that the locking plug (10) is in place in the inside bearing race. The locked bearing must be fitted to the rotor case so that it will be locked in place between the shoulder on the socket (13) and the shims (9) against the rotor case. Make this adjustment as follows:

1. Shims (9) are added between the outer bearing race and case (8) until a .0015-inch feeler gage can just be inserted between the case and the flange of the socket, when socket with bearing installed is held firmly in place. (See figure 200.)

2. The bearing and socket are then removed and .001-inch thickness of shims (9, figure 171) are removed from behind the bearing. Thus, when the bearing is replaced, clearance between the socket flange and the case will be .0005-inch. Then, when the screws (14) are tightened, the bearing will be securely locked against the housing. More than .0005-inch clearance before tightening may cause distortion of the socket and outer bearing race, thus creating friction in the bearing, which would prevent correct operation of the gyro.

(e) Match up the scribe marks on the bearing socket (13) and on the rotor case (8), and fasten the

bearing socket to the rotor case with the four 4-40x 5/16-inch flathead screws (14).

(f) Remove the free bearing (6) and socket (5) from the covered container into which they were placed after washing and lubricating. Make sure that the locking plug (7) is in place in the inside race of the bearing; and, matching the scribe marks on the socket and case, insert the socket and bearing into the recess in the case, securing the socket to the case with four 4-40x 5/16-inch flathead screws (4).

CAUTION

These bearings were oiled after washing and inspection. Do not re-oil bearings in reassembling. Too much oil creates unnecessary friction.

(13) **SPIN BALANCE ROTOR AND CASE ASSEMBLY.**—For ease in balancing about axis 2, as described in this section, paragraph 2, a, (2), the rotor and case assembly is first "spin" balanced to make sure that Plane 1 divides its weight equally. (See figure 201.) It is also advisable to "spin" balance about Plane 2. (See figure 202.) Accurate "spin" balancing about these two planes gives a balanced rotor and case assembly. Thus, in subsequent balancing operations, where the rotor and case assembly is part of the unit being balanced, any unbalance will *not* be caused by unbalance of the rotor and case assembly and therefore indicates unbalance of the other parts of the assembly. Correction can then be made on these other parts rather than on the rotor and case assembly.

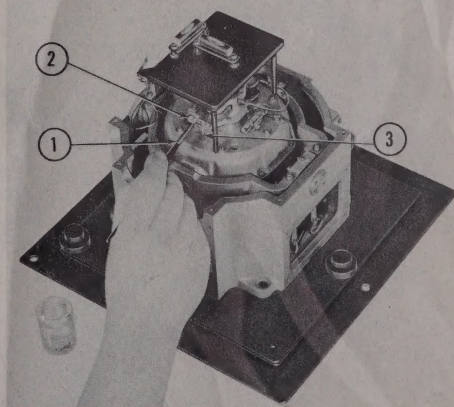


Figure 205 — Cementing Level Vials in Place

Index No.	Nomenclature
1.	Brush
2.	Level Vials
3.	Locking Screw

(a) Support rotor and case assembly on a spin balance stand, as shown in figure 201.

(b) (See figure 158.) Rotate assembly to position shown, and balance by adding weights at points 3, 4 and 12, or 6, 7 and 10 (depending on which side is heavy) to obtain balance about the plane, as shown in figure 201.

(c) Rotate assembly to position shown in figure 202. Balance by adding weights at points (figure 158) 5 and 13, or 8 and 11 (depending on which side is heavy) to obtain balance about the plane, as shown in figure 202.

(d) Careful spin balancing at this point will greatly simplify balancing of rotor housing and cardan assembly, outlined in this section, paragraph 2, e, (23).

(14) ASSEMBLE ROTOR AND CASE ASSEMBLY INTO CARDAN ASSEMBLY.

(See figure 171.)

(a) With the rotor and case assembly still mounted on the rotor case stand, slip the cardan assembly over the rotor case, with the small terminal block on the side of the cardan next to the erecting cut-out magnet.

(b) Insert the free bearing gudgeon pin (3) through the cardan, on the side opposite the erecting cut-out magnet, and into the free bearing (6).

(c) Insert the locked bearing gudgeon pin (15) through the cardan on the side next to the erecting cut-out magnet and into the locked bearing (11).

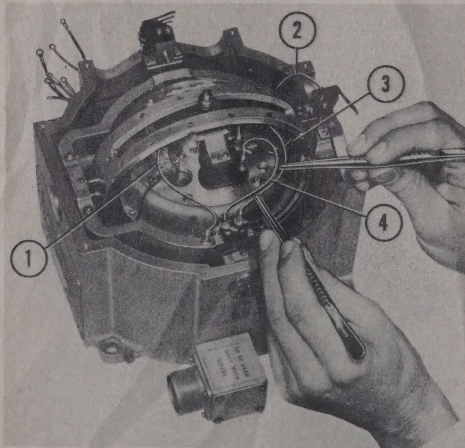


Figure 206 — Shaping Flex Leads

Index No.	Nomenclature
1.	Flex Lead
2.	Flex Lead
3.	Flex Lead
4.	Flex Lead

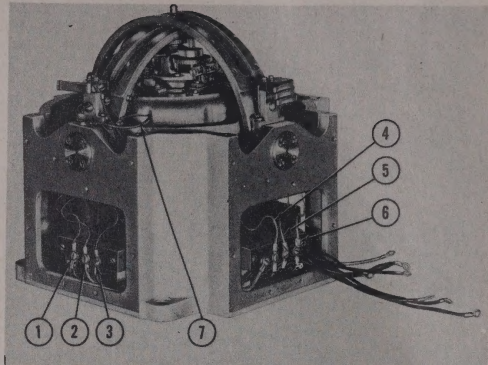


Figure 207 — Proper Shape of Wiper Flex Leads

Index No. Nomenclature

1.	Terminal
2.	Terminal
3.	Terminal
4.	Flex Lead
5.	Flex Lead
6.	Flex Lead
7.	Flex Lead

(d) Secure each gudgeon pin to the cardan with four 4-40x5/16-inch flathead screws (1 and 16). After pulling these screws up tight, insert the locking screws (2) through the center of gudgeon pins, and screw them tightly into the locking plugs (7 and 10) to lock the bearings tightly to the pins.

(e) Loosen the locking screw in the locked bearing (11), checking to see that the rotor case may be pushed at least .006 inch away from the locked bearing gudgeon pin (15). This movement can be observed by watching the movement of the locking screw. If there is any question as to whether or not this clearance is at least .006 inch, the clearance should be checked with thickness gage between the shoulder of the locking screw and the gudgeon pin. Insufficient clearance may be corrected by shimming between the free bearing gudgeon pin (3) and the cardan. Then retighten the locking screw in the locked bearing gudgeon pin (15).

(15) CHECK FOR TOP OR BOTTOM HEAVINESS.

(a) Using two pins inserted in the holes provided for access to the rotor balancing screws (figure 198), press down on the rotor to make sure that the lower rotor bearing is seated against the shoulder at the bottom of the case.

(b) Remove the rotor case and cardan assembly from the rotor case stand, and set the cardan up on the end opposite the single wiper.

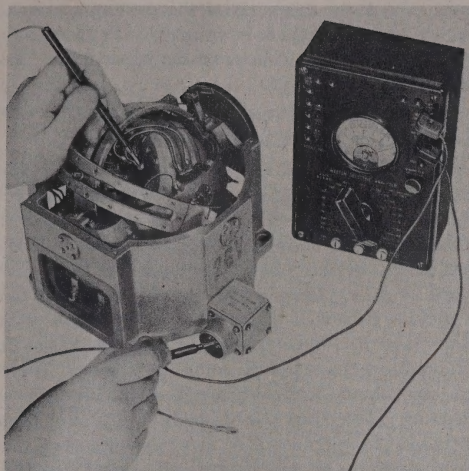


Figure 208 — Checking Continuity of Wiring With Ohmmeter

(c) In this position, check for any extreme top or bottom heaviness of the rotor case assembly.

(d) *It is only necessary at this point to determine extreme unbalance which could not be corrected by adding weight to the top or bottom of the rotor case.* When such an extreme unbalance occurs, it is necessary to remove the rotor case assembly from the cardan, disassemble the rotor case, and add or subtract shims from beneath the lower rotor bearing, thus shifting the rotor weight toward the lighter end of the case. When this is done, recheck to be sure there is some end play of the rotor in the case, and if necessary to provide this end play, place shims under the erecting cut-out frame assembly.

(e) An accurate balance about this plane will be performed at a later point in reassembly.

(16) ASSEMBLE ROTOR CASE AND CARDAN ASSEMBLY INTO GYRO HOUSING.

(See figure 166.)

(a) Remove the cardan bearings from the covered container into which they were placed after washing, inspection, and lubrication. Press each cardan bearing firmly up against the shoulder in the cardan, making sure that each bearing is replaced in the end from which it was removed. If new bearings are used, be sure that the new bearings are placed in the side to which they were fitted.

(b) Place the rotor stand through the bottom of the housing; lower the rotor case and cardan assembly into the housing until the rotor case rests properly on

the rotor case stand. Be sure that the single wiper is over the three-terminal block in the housing.

(c) Insert the No. 2 and No. 4 gudgeon pins (2 and 4) through the housing in the correct position, with the scribe marks on the top. Remember that these gudgeon pins are numbered counterclockwise from the AN receptacle, with the No. 1 gudgeon pin directly over the receptacle. Be sure to replace all shims (8) removed with these gudgeon pins under the gudgeon pins with which they were removed. Press the gudgeon pins into place so that the cardan bearings are resting properly on the gudgeon pins, securing each gudgeon pin in place with four 4-40x3/8-inch flathead screws (5).

(d) (See figure 203.) Using a taper gage (3) or a thickness gage, check the end play of the cardan (1) in the housing (2) between the No. 2 and No. 4 gudgeon pins. This end play should not be less than .003 inch, or more than .006 inch. If insufficient end play is indicated, add an equal amount of shims under the No. 2 and No. 4 gudgeon pins to provide for the correct clearance. If too much end play is indicated, shims may be removed from under these gudgeon pins; or if this does not reduce end play sufficiently, shims may be added between the cardan bearing and the shoulder against which the cardan bearings seat. (Do not remove gage between readings as clearance may not be the same in all positions.)

(17) LEVEL ROTOR CASE ON LEVELING PLATE. (See figure 204.)

(a) With the rotor case stand still supporting the rotor case, place the rotor case, cardan, and gyro housing assembly on the leveling plate (5).

(b) Place master level gage (tripod precision table) (3) on top of rotor case so that each of the level vials (2) on the master level gage (3) is parallel to one of the level vials on the rotor case.

(c) Adjust the leveling screws (6) in the leveling plate so that both level vial bubbles on the master level gage are exactly centered. *When this adjustment is properly made, the rotor spindle will then be exactly vertical.*

(18) ADJUST LEVEL VIALS ON ROTOR CASE. (See figure 204.)

(a) With the rotor case leveled on the leveling plate, loosen the locking screw (1), and rotate the level vial bracket until the bubble is in the center position and tighten the locking screw slightly.

(b) Precise adjustment of the leveling vial may now be made by first rotating the level vial in the bracket until the graduations are exactly on top; then, using a screw driver under the low side of the bracket, as shown, pry up carefully until the bubble is exactly centered.

(c) (See figure 205.) When sure that bubble in level vial is exactly centered and graduation lines are on top and the center graduation exactly over the locking screw, tighten locking screw securely and place a drop of cement on the bracket fingers holding the glass level vials (2) and on the head of the locking screw (3), to make sure that the adjustment will not be disturbed.

(19) INSTALL FLEX LEADS. (See figure 206.)

(a) Connect two 4 $\frac{3}{4}$ -inch flex leads (1 and 3) from the small motor terminal block on the rotor housing to the two-pole terminal block on the cardan and from the motor ground connection on the rotor case to the cardan ground connection respectively, using four 3-48x $\frac{1}{4}$ -inch binding head screws. Connect a 4 $\frac{1}{4}$ -inch flex lead (4) from the erecting cut-out magnet terminal on the magnet to the two-terminal block on the cardan using two 3-48x $\frac{1}{4}$ -inch binding head screws.

CAUTION

When connecting flex leads (4) to the magnet, hold the lug so that it does not turn and thus twist off the fine wire attached to the magnet lug.

(b) Connect a 4-inch flex lead (2) as a ground connection between the cardan and the case on the side next to the single (elevator) wiper, using two 3-48x $\frac{1}{4}$ -inch binding head screws.

(c) (See figure 207.) Connect three 4-inch flex leads from the three-terminal block on the under side of the cardan to the three-terminal block terminal (1, 2, and 3) on the housing below the single (elevator) wiper, using three 4-40x5/16-inch binding head screws to make the connection to the three-terminal block on the housing. (Do not cross flex leads.)

(d) (See figure 206.) Make sure that all flex lead lugs are properly positioned. The position of these lugs will affect the balance of the gyro and aid in the shaping of the flex leads.

(e) Proper shaping of flex leads is shown in figures 206 and 207. Form all flex leads as indicated so that for any position of the rotor or cardan they do not touch themselves, or any part of rotor case or cardan assembly.

(f) (See figure 208.) Use an ohmmeter to check the continuity between the ground terminal on top of the rotor case and the ground lead to the gyro housing. Check the continuity between the motor lead at the small terminal block on top of the rotor housing and the M-prong of the AN connector. Check continuity between the terminal of the erecting cut-out magnet and the N-prong on the AN connector. If continuity is not found in each of these checks, check wiring to find where the wrong connection has been

made. Check the operation of the erecting cut-out to see that when the magnet is energized with 26 volts dc, the roller gear drops away from the upper roller. Repeat this test at 15 volts.

(20) ALIGN ROTOR SPINDLE WITH
CARDAN BEARING AXIS.

(a) In order to obtain satisfactory gyro operation and correct operation of the lower bail, the axis of the rotor and the axis of rotation of the cardan in its bearings (Axis 2, figure 155) must lie exactly in the same plane. Because one of the rotor case bearings is locked to the cardan and the opposite bearing is free to slide in its socket, the axis of the rotor will move away from the locked bearing as the gyro begins to heat up in operation and the rotor case expands. Therefore, this alignment must be checked with the gyro at operating temperature. If properly set in alignment when hot, the spindle will be approximately .0005 inch out of alignment toward the locked bearing, when cold.

(b) (See figure 166.) Install bottom bail bushings

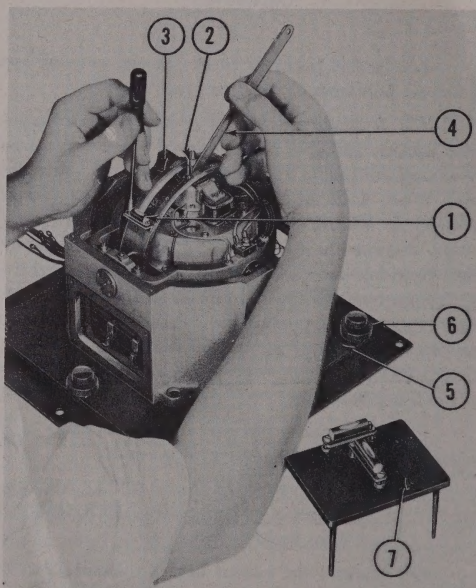


Figure 209 — Aligning Rotor Axis With Cardan Axis

Index No.	Nomenclature
1.	Level Vial
2.	Erecting Roller
3.	Aligning Jig
4.	Thickness Gage
5.	Leveling Plate
6.	Adjusting Screw
7.	Master Level Gage

on the No. 2 and No. 4 gudgeon pins (2 and 4), making sure to see that the correct bushing is placed on the correct pin. Install bottom bail on the bushings, locking it in place by means of the retaining lug on one side and the retaining screw on the other.

(c) Connect a 26-volt dc power source to the M-prong of the AN receptacle and to the housing ground lead. Place the rotor in a vertical position, and allow the gyro to run for about 1½ hours to warm up. Keep gyro covered during entire warm-up period. After warm-up remove bottom bail. Listen carefully for noisy operation of erecting cut-out mechanism, particularly if individual parts of the assembly have been replaced. If mechanism is extremely noisy or seems to bind, replace it.

CAUTION

A few gyros are designed to operate on 13 volts dc instead of 26 volts dc. Make sure of voltage as follows:

26-volt units:

- Red leads to motor field coils.
- Housing stamped "26 V," or AN receptacle painted red.
- Red dot may be found on erecting cut-out magnet.

13-volt units:

- Black leads to motor field coils.
- Housing may be stamped "13 V."
- No color on AN receptacle.
- Blue dot may be found on erecting cut-out magnet.

(d) (See figure 209.) Mount rotor case on rotor case stand through bottom of housing. Place entire unit, with stand in place, on leveling plate. Turn leveling screws (6, figure 204) on leveling plate until level vials show rotor to be exactly level. Check level with master level gage (3), as shown.

Note

The aligning jigs used to adjust the alignment of the rotor spindle with the axes of balance are constructed (figure 210) from discarded bails, with the bail corks and retainers removed and fitted with an adjustable level vial on one end. The bottom bail, used to construct this jig, should have the retaining pin cut off.

(e) (See figure 209.) Place aligning jig (3) (made from bottom bail) on bottom bail bushings.

(f) Insert a thickness gage (4) of about .006-inch thickness between reference side of jig and erecting roller (2); and, holding jig tightly against thickness gage and roller, adjust level vial (1) to read zero (level).

(g) Reverse aligning jig end for end, and insert thickness gages of different thicknesses between reference side of jig (3) and roller (2) until level gage again reads zero (level).

(h) When the spindle is properly aligned, the same thickness gage will be required for a level reading in each position. If the spindle is not in line, subtract the smaller thickness of gage from the larger thickness, and divide by two to determine the distance which the rotor and case assembly must be moved toward the side of the thicker gage to bring it into alignment.

(i) (See figure 171.) To shift the rotor and case assembly away from the locked bearing (11), add shims (9) between the bearing (11) and the case (8) and an exactly equal number of shims (12) between the locked bearing socket (13) and case (8). If exactly the same number of shims are not added in each case, either the bearing will not be locked or the socket will be distorted.

(j) To shift the rotor and case assembly toward the locked bearing, remove the required number of shims (9) from under the bearing (11) and exactly the same number of shims (12) from under the locked bearing socket (13). If either the shims (9) under the bearing or the shims (12) under the socket total in thickness less than the amount that the rotor case must be shifted toward the locked bearing, do not touch these shims and, instead, add the correct thickness of shims between the locked bearing gudgeon pin (15) and the cardan. If shims are removed from under the bearing and under the socket, be sure that exactly the same thickness of shims (9) are removed from under the bearing as shims (12) are removed from under the socket. Otherwise either the bearing will not be locked or it will be distorted.

(k) To shift the rotor and case assembly as outlined in the two preceding steps, follow disassembly

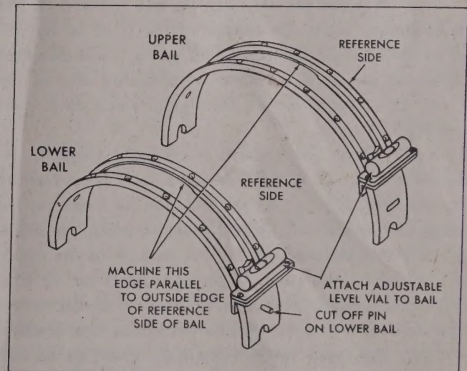


Figure 210 — Aligning Jigs

procedure for removing rotor case and cardan assembly from the housing and rotor and case from cardan, as outlined in this section, paragraph 2, (c), (5) and (7). Then follow reassembly procedure to this point and again warm up gyro, level it on plate, and test for alignment, as above.

(21) ALIGN ROTOR SPINDLE WITH GUIDE CHANNEL BEARING AXIS.

(a) To obtain satisfactory gyro action and correct operation of the upper bail, the axis of the rotor and the axis of rotation of the counterbalance guide channel in its bearings (Axis 2, *figure 155*) must lie exactly in the same plane. Since the temperature of the gyro will not affect the position of the rotor spindle in this plane, this alignment may be made without warming up the unit.

(b) (See *figure 209*.) Mount rotor case on rotor case stand through bottom of housing. Place entire unit, with stand, in place on leveling plate. Turn adjusting screws (6, *figure 204*) on leveling plate until level vials show rotor to be exactly level. Check level with master level gage (3).

(c) Insert the No. 1 and No. 3 gudgeon pins into the housing, taking care to line up the scribe marks, and secure each gudgeon pin with two 4-40x $\frac{3}{8}$ -inch flathead screws in each gudgeon pin. Place the correct bail bushings on the inside ends of these pins. Then place the aligning jig, made from top bail (*figure 210*) on top bail bushings.

(d) Since the cardan has from .003 to .006-inch end play on the No. 2 and No. 4 gudgeon pins, this end play must be taken into account when aligning the rotor spindle with the guide channel bearing axis. Slide the cardan to the limit of its end play in one direction and insert a thickness gage of about .006-inch thickness between the reference side of jig and erecting roller, and, holding the jig tightly against the thickness gage and roller, adjust level vial to read zero (level).

(e) Reverse the aligning jig end for end on the bail bushings. Slide the cardan to the limit of its end play in the *opposite* direction, and insert thickness gages of different thickness between the reference side of the jig and the roller until the level gage again reads zero (level).

(f) When the spindle is properly aligned, the same thickness gage will be required for a level reading with the aligning jig in one position and the cardan pushed to one limit of its end play, as when the aligning jig is reversed and the cardan pushed to the opposite limit of its end play. If the spindle is not in line, subtract the smaller thickness of gage from the larger thickness and divide by two to determine the distance the rotor case and cardan assembly must be moved toward the side of the thicker gage to bring it into alignment.

CAUTION

When checking for alignment in this axis, always take one reading with the cardan pushed to the limit of its end play in one direction and the other reading with the cardan pushed to the limit of its end play in the opposite direction.

(g) (See *figure 166*.) Shift the rotor case and cardan assembly the required distance by removing shims of a thickness equal to one-half of the distance to be moved, from the gudgeon pin (2 or 4) on the side next to the smaller thickness of gage, and adding these same shims under the opposite gudgeon pin. This will not affect the end play of the cardan. Then recheck alignment.

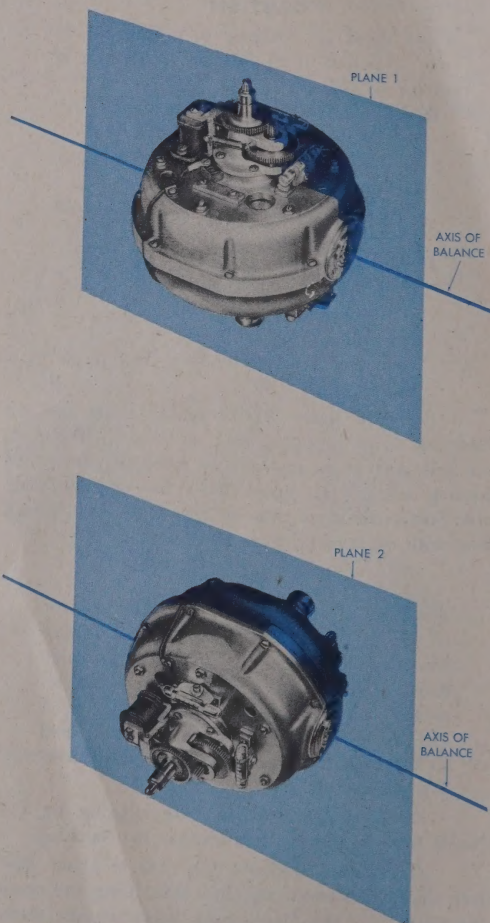


Figure 211 — Balance of Rotor and Case Assembly (Axis 1)

(22) **BALANCE THE ROTOR ASSEMBLY IN THE CARDAN.**—(Balance about Axis 1—See figure 211.)—For ease in balancing axis 1, the rotor and case assembly is first balanced about this axis while supported by the rotor case bearings in the cardan. Secondly the counterbalance guide channel and top bail assembly are added, and the entire unit is balanced about this axis. (See figure 220.) Thus, in this second balancing operation, described in this section, paragraph 2, e, (25), any unbalance *must* be caused by unbalance of the counterbalance guide channel and top bail assembly, and correcting weights need be added only to the counterbalance guide channel.

Note

Review theory of balance, this section, paragraph 2, a, (2), before attempting any balancing operations.

(a) Install the bottom bail bushings on the No. 2 and No. 4 gudgeon pin, taking care to see that the proper bushing is installed on the proper gudgeon pin. Install the bottom bail on the bushings, locking it in place by means of the retaining lug on one side and the retaining screw on the other. Connect a 26-volt dc power source to the M-prong on the AN receptacle and to the ground lead on the gyro case. Place the rotor in a vertical position, and allow the gyro to run for about 1½ hours to warm up. Be sure to cover the entire gyro during the entire warm-up period. Disconnect power supply, and allow gyro to come to a stop.

CAUTION

A few gyros are designed to operate on 13 volts dc instead of 26 volts dc. Make sure of voltage as follows:

26-volt units:

Red leads to motor field coils.

Housing stamped "26 V," or AN recep-

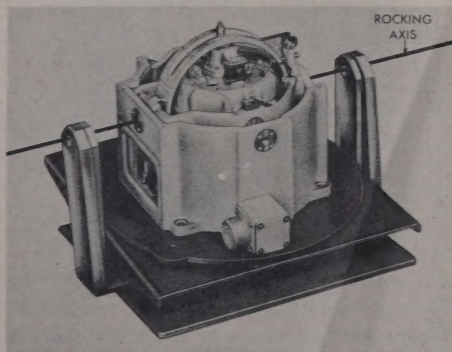


Figure 212 — Rocking Table

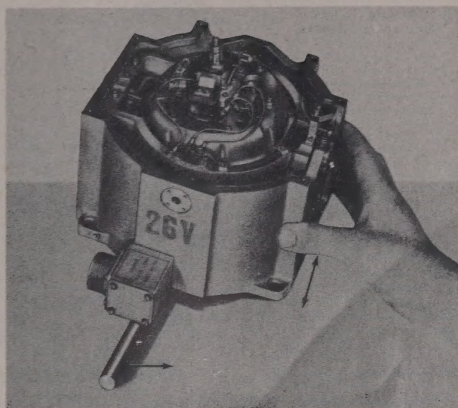


Figure 213 — Rocking to Determine Rotor and Case Balance About Plane 1 (Axis 1)

tacle painted red.

Red dot may be found on erecting cut-out magnet.

13-volt units:

Black leads to motor field coils.

Housing may be stamped "13 V."

No color on AN receptacle.

Blue dot may be found on erecting cut-out magnet.

(b) After the gyro is thoroughly warmed, as outlined in (a) preceding, remove the bottom bail and bail bushings, and proceed to check the balance of the rotor and case assembly in the cardan, as follows:

1. If a rocking table (figure 212) is not available, place a cylindrical object (such as a piece of pipe or wooden dowel at least ¾-inch in diameter) under the housing directly below the rotor case bearing. By grasping the housing, as shown in figure 213, and moving the edge of the housing up and down, as indicated, it is possible to rock the housing on the roller rapidly and evenly to relieve the static friction on the bearings, in the same manner as this is done on a rocking table. By relieving the static friction on the bearings in this way, any slight unbalance, which was not enough to overcome the static friction of the bearings when it was stationary, will cause the heavier side to rotate toward a lower position. *An even rocking motion is absolutely necessary.*

2. When rocked in this manner, heaviness on either side of a vertical plane through the rotor case bearings (figure 211-A) will cause the rotor case to tip toward the heavy side. Before adding weight to compensate for heaviness on either side, the rotor case

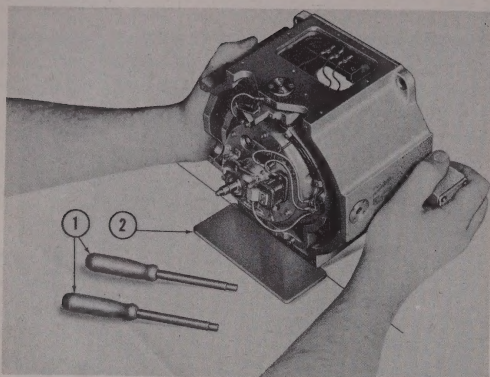


Figure 214 — Rocking to Determine Rotor and Case Balance About Plane II (Axis II)

Index No.	Nomenclature
1.	Reseating Pins
2.	Plate

should be checked for top or bottom heaviness, as described in the next step, so that the counterbalancing weights may be properly placed.

3. Make sure that the rotor is seated in the case by pressing down with two rods through the holes provided for access to the rotor balancing screws (figure 198). Then turn the gyro housing up on its side so that it rests on its flat surface opposite the single wiper (figure 214). Place a thin plate (2) under the edge of the housing so that the gudgeon pin does not rest on the table. Rocking in this position will permit a check of the top or bottom heaviness of the rotor and case assembly (figure 211-B).

CAUTION

If at any time in this check the top of the rotor case tips below the horizontal it is possible that the rotor may shift toward the top of the case. This, of course, prevents accurate balancing until the rotor is again seated properly, as outlined above.

4. Rock the gyro housing rapidly and evenly about the point where the top edge rests against the plate (figure 214) to relieve the static friction on the bearings. Check to see if the top or bottom of the rotor and case assembly appears to be heavy. Determination has now been made as to whether the rotor and case assembly is top-or-bottom-heavy, and, in the preceding step, which side is heavy.

5. If bottom heaviness was indicated, correct this heaviness by subtracting weight from the bottom on the heavy side, or, if necessary, adding weight on the top and on the side opposite to the heavy side; or, if neither side was heavy, distribute the weight evenly

under top side balance screws indicated in figure 158, A and B. If top heaviness was indicated, subtract weight from the top or add weight to the bottom, in like manner. Recheck balance about two planes (figure 211), as directed in steps 2. and 4. above; add, or remove, weights until accurate balance is obtained.

(23) **BALANCE THE ROTOR CASE AND CARDAN ASSEMBLY.** (Balance about Axis 2, figure 155.)—For ease in balancing about Axis 2 (figure 215) the rotor and case assembly was first "spin" balanced (this section, paragraph 2, e, (13)) to make sure that plane 1 divides its weight equally (figure 201). It is also advisable to "spin" balance about Plane 2 (figure 202), as it makes subsequent balancing operations easier. The rotor and case assembly

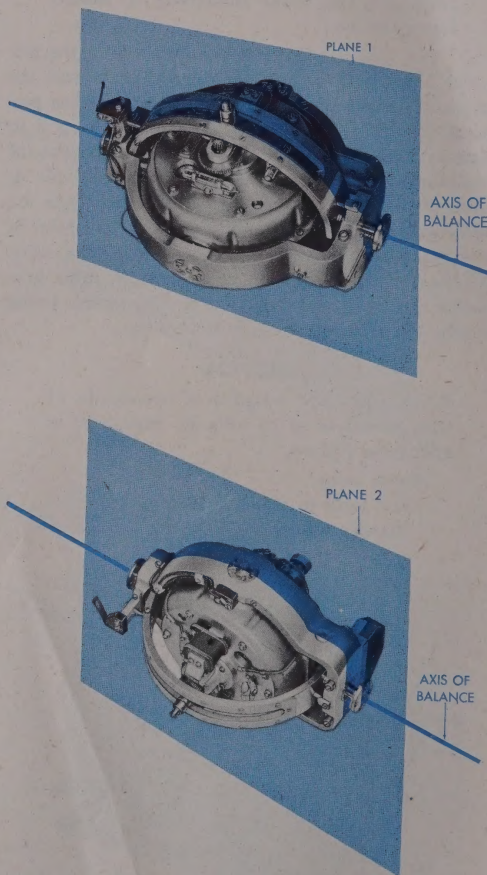


Figure 215 — Balance of Case and Cardan Assembly About Plane I and Plane II (Axis II)

was also balanced about Axis 1 through the rotor case bearings (figure 211) so that there is no top or bottom heaviness to affect balance about Axis 2. Then, if the rotor and case assembly is properly centered in the cardan (this section, paragraph 2, e, (20)), unbalance about Axis 2 can be caused only by unbalance of the cardan and bottom bail assembly, and weights need be added only to the cardan to give balance about Axis 2. (See figure 215.) *An accurate balance about Axis 2 can only be obtained when the gyro is at operating temperature, since, when the unit is cold, contraction of the metals pulls the rotor and case assembly slightly off center toward the locked bearing, thus throwing the unit out of balance around Axis 2.*

(a) Install the bottom bail and bail bushings, and allow the gyro to warm up again for about 1/2 hour.

(b) In balancing the rotor case and cardan assembly, the bottom bail must remain in place and should not be removed as it was in obtaining the rotor case balance. It is necessary, however, in balancing about Plane 1 (figure 216) to lock the spindle in position in the lower bail by placing a shim of paper or cardboard (1) around the lower roller so that the roller cannot move and is spaced equally between the two sides of the lower bail. This should be done with the spindle in the center position.

(c) With the gyro properly warmed up, the bottom bail in place, and the roller locked in position in the bottom bail, proceed to check the cardan balance, as follows:

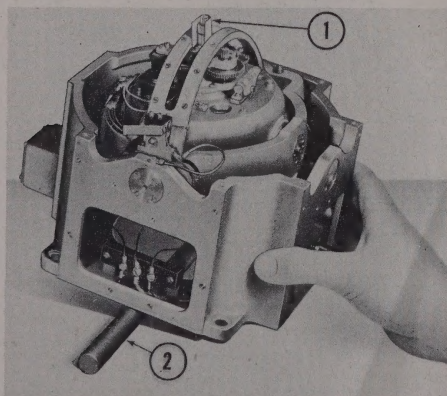


Figure 216 — Rocking to Determine Rotor Case and Cardan Balance About Plane I (Axis II)

Index No.	Nomenclature
1.	Cardboard Shim
2.	Roller

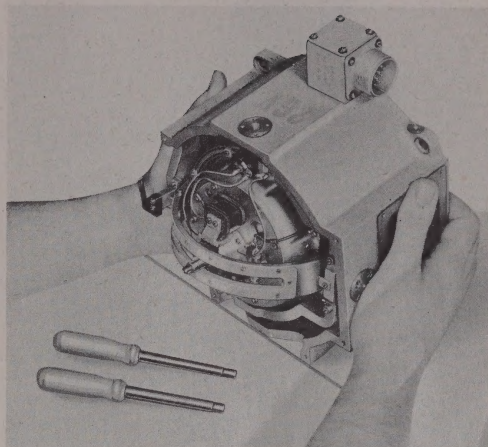


Figure 217 — Rocking to Determine Rotor Case and Cardan Balance About Plane II (Axis II)

1. Place the gyro housing to an upright position, and balance the rotor case and cardan assembly about Plane 1 (figure 215-A) through the cardan bearings. Insert a roller (a round pipe, or wooden dowel, at least 3/4-inch in diameter) (2, figure 216) across under the housing, directly below the cardan bearings. Grasp the side of the gyro housing; move it up and down to give a rapid and even rocking motion on the roller. This will relieve the static friction of the bearings and give an indication of which side of the rotor case and cardan assembly is heavy, when balancing about this vertical plane (Plane 1) through the cardan bearings.

CAUTION

It is impossible to obtain the correct balance about this plane if the locked bearing was not properly secured in making the adjustments outlined in this section, paragraph 2, e, (12). In making this balance it is also important that the gyro be at operating temperature, since, if it has cooled down, the rotor case will have contracted and moved the rotor case weight toward the locked bearing, thus giving an unbalance which would indicate heaviness on the locked bearing side.

2. Add weight to the lighter side, or subtract weight from the heavy side at points 1 or 2 (figure 159) to correct for unbalance of the rotor case and cardan assembly about this plane; then recheck to make sure that this balance is correct.

3. Remove the paper shim; turn the gyro hous-

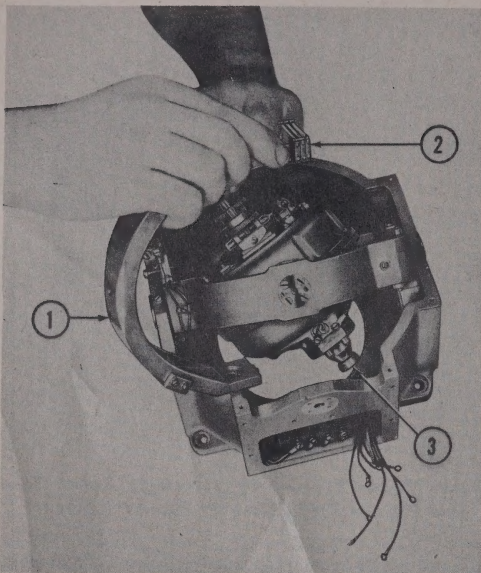


Figure 218 — Inserting Counterbalance Guide Channel

Index No.	Nomenclature
1.	Guide Channel
2.	Triple Wiper
3.	Guide Roller

ing up so that it is resting on the side into which the No. 3 gudgeon pin is to be inserted (*figure 217*). Rock the gyro housing back and forth rapidly and evenly about the line where the top edge of the housing contacts the table. This will relieve the static friction in the bearing and permit determination of heaviness on either side of Plane 2 (*figure 215-B*) through the cardan bearings.

CAUTION

In making this balance, it is very important to be sure that the rotor is properly seated (*figure 198*) in the rotor case before attempting to check the balance in this plane. To make sure that the rotor is seated, press it down firmly, using two pins (1, *figure 217*) through the holes provided for access to the rotor balance screws. If at any time in the balancing operation the top of the rotor case tips below the horizontal it is possible that the rotor might shift towards the top of the case. Use the pins to push it back in place before attempting to make an accurate balance.

4. After checking the balance in this way to

determine top or bottom heaviness, add or remove the necessary weight at points 3, 4, or 5 (*figure 159*) to bring the rotor case and cardan assembly into balance. It is preferable to remove weight from the heavy side, if possible, rather than to add weight to the light side. After adding or subtracting the proper weight, check again to make sure that the rotor case and cardan assembly is exactly in balance.

(24) INSTALL COUNTERBALANCE GUIDE CHANNEL AND TOP BAIL ASSEMBLY.

(a) Remove the counterbalance guide channel bearings from the covered containers in which they were placed after washing and lubricating. With the fingers, push these bearings into place in the counterbalance guide channel, taking care to see that the proper bearing is inserted on the proper side for which it was fitted.

(b) Remove the bottom bail and bottom bail bushings from the unit.

(c) Grasp the rotor spindle with one hand, tip it over toward the AN receptacle (*figure 218*), and insert the counterbalance guide channel (1) from the opposite side. Be very careful not to jam or twist the flex leads attached to the counterbalance guide channel at the triple wiper end (2). Make sure that the guide roller (3) falls into the channel of the counterbalance guide channel as it finally reaches its correct position.

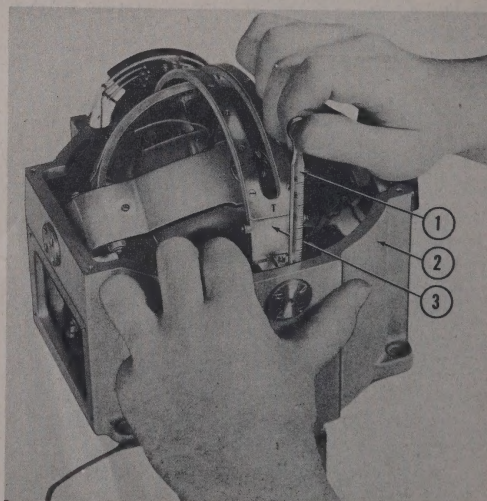


Figure 219 — Checking End Play of Guide Channel

Index No.	Nomenclature
1.	Taper Gage
2.	Housing
3.	Guide Channel

(d) Insert gudgeon pins Nos. 1 and 3 in their proper positions through the housing and the counter-balance guide channel bearings; secure each gudgeon pin to the housing with one 4-40x $\frac{3}{8}$ -inch flathead screw.

(e) (See figure 219.) Use a taper gage (1) or thickness gage to check the end play of the counter-balance guide channel (3) on the gudgeon pins by first pushing the channel as far as it will go one way, measuring the clearance between the channel (3) and

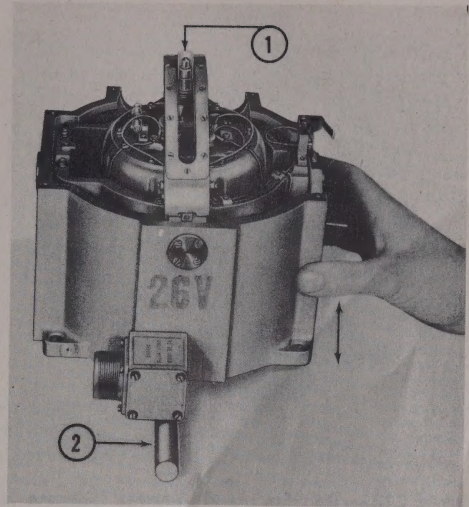


Figure 221 — Rocking to Determine Balance of Guide Channel and Top Bail About Plane 1 (Axis I)

Index No.	Nomenclature
1.	Cardboard Shim
2.	Roller

the gyro housing (2), then pushing it as far as it will go the other way, and again taking the measurements. This end play must be between .003 and .010 inch. Insufficient end play can be corrected by adding shims beneath the gudgeon pins, and too much end play can be corrected by adding shims beneath the counter-balance guide channel bearings. When end play is correct, install the remaining three 4-40x $\frac{3}{8}$ -inch flat-head screws in each gudgeon pin.

(f) (See figure 166.) Place the top bail bushings in place on the ends of gudgeon pins Nos. 1 and 3, taking care that each bushing is installed on the pin to which it was fitted. Put the top bail assembly in place on the top bail bushing; secure the bail in place by turning the locking lug into the slot on the bail, fastening it in position, and screwing in the retaining pin from the opposite side.

(g) (See figure 207.) Connect the flex lead from the top wiper (4), from the middle wiper (5), and from the bottom wiper (6) to terminals on the four-terminal block, as shown in figure 207, using 4-40x $\frac{5}{16}$ -inch binding head screws. Make these connections, at the same time connecting the three wires from the wiring harness which also go to these three terminals. The correct wire for each terminal may be determined by checking it out against the proper pole of the AN

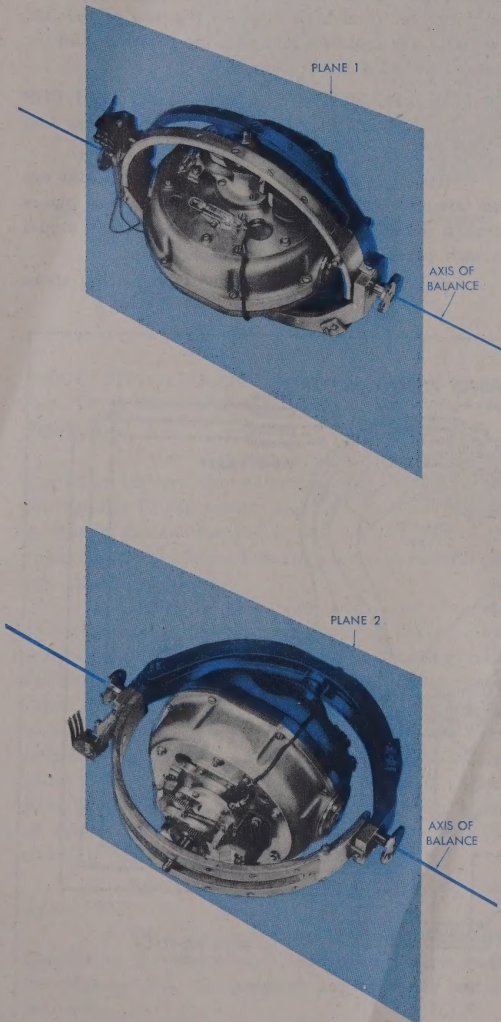


Figure 220 — Balance of Guide Channel and Rotor Case (Axis I)

receptacle, using an ohmmeter to determine continuity. The wire from the B-prong of the AN connector con-

nects to the top wiper terminal (4). Wire from the K-prong of the AN receptacle connects to the middle wiper terminal (5), and the wire from the I-prong of the AN receptacle connects to the bottom wiper terminal (6).

(b) (See figure 207.) After making these connections, shape the flex leads carefully so that there will be no kinks in the leads, and any spring action in the leads will not affect the balance of the top bail and counterbalance guide channel assembly. Large sweeping curves are desirable. To make sure that the connections were properly made, it is best to check the top wiper for continuity with the B-prong of the AN receptacle, the middle wiper with the K-prong, and the lower wiper with the I-prong.

(25) BALANCE GUIDE CHANNEL AND TOP BAIL ASSEMBLY. (Balance about Axis 1, See figure 220.)

(a) The counterbalance guide channel and top bail assembly must be balanced about two planes through the gudgeon pins Nos. 1 and 3, at right angles to each other.

(b) This is the second step in balancing about

Figure 222 — Rocking to Determine Balance of Guide Channel and Top Bail About Plane II (Axis I)

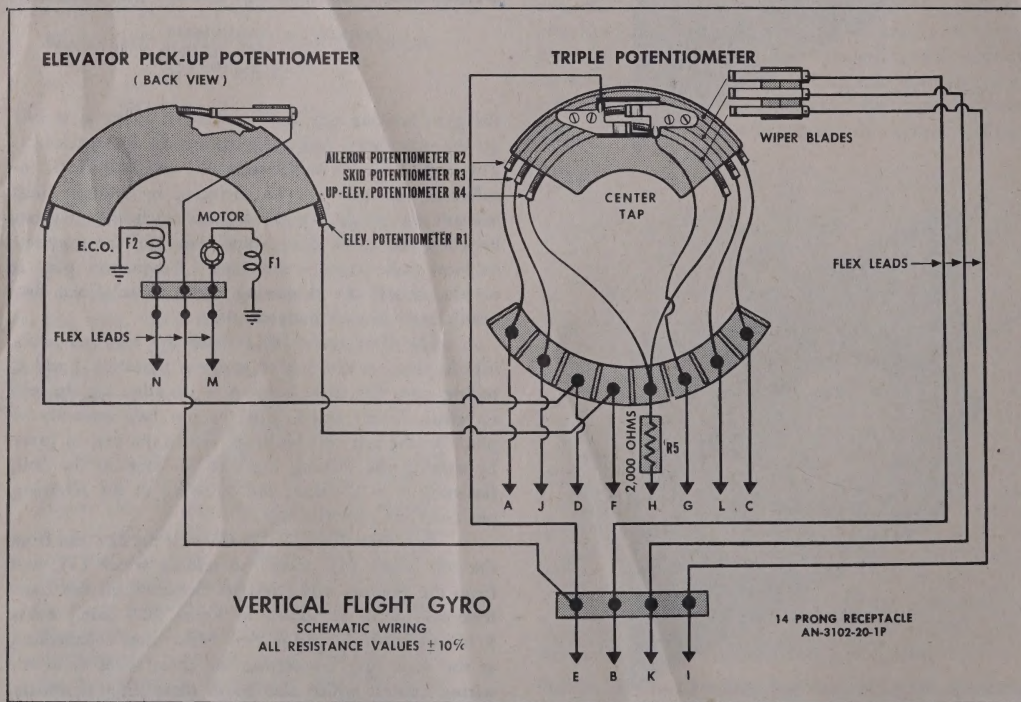


Figure 223 — Flight Gyro Wiring Diagram

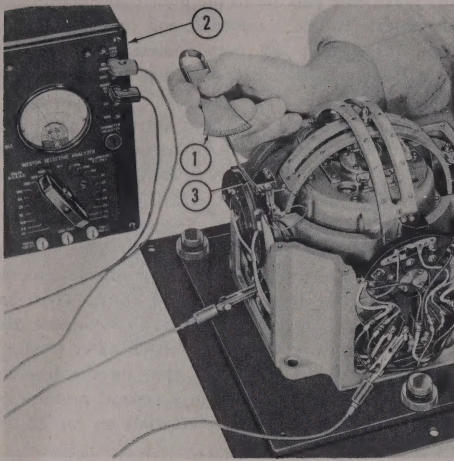


Figure 224 — Testing Wiper Blade Tension

Index No.	Nomenclature
1.	Gram Gage
2.	Ohmmeter
3.	Wiper Blade

Axis 1 (figure 155) and completes balance about this axis. Check the balance about Plane 1, as follows: (See figure 221.)

1. Using a cardboard shim (1) around the top roller between the roller and the top bail, secure the spindle in the center position. Be sure that the cardboard shim is wrapped equally on each side of the roller so that the roller is exactly centered between the two sides of the bail.

2. Insert the roller (2) used in previous balancing operations under the gyro housing, directly under gudgeon pins Nos. 1 and 3. Grasp the housing under the single wiper; move this edge of the housing up and down to rock the housing rapidly and evenly on the roller. This will reduce the static friction on the counterbalance guide channel bearings so that unbalance about Plane 1 (figure 220) may be observed. Determine which side of the bail seems heavy. Make a note of this so that this unbalance can be corrected after checking balance about Plane 2 (figure 220).

(c) Balance about Plane 2, as follows: (See figure 222.)

1. Turn the gyro housing over on the side opposite to the single wiper, and place a plate under the edge so that the gudgeon pin does not rest on the table.

2. Rock rapidly and evenly about the upper edge of the gyro housing to relieve static friction on

the counterbalance guide channel bearings. Note any top or bottom heaviness.

CAUTION

In making this balance, it is very important to be sure that the rotor is properly seated (figure 198) in the rotor case before attempting to check the balance in this plane. To make sure that the rotor is seated, press it down firmly, using two pins (1, figure 217), through the holes provided for access to the rotor balance screws. If at any time in the balancing operation the top of the rotor case tips below the horizontal, it is possible that the rotor might shift towards the top of the case. Use the pins to push it back in place before attempting to make an accurate balance.

(d) Correction for unbalance in a counterbalance guide channel and top bail assembly is made only at the lead counterbalance weight points 1, 2, and 3 (figure 160). For top heaviness, add weights at this point, being careful to add them on the side (point 1 or 2) which appears light in the first balance about Plane 1. For bottom heaviness, subtract weights at this point, being careful to subtract them from the side which appeared heavy in the first balance about Plane 1. If no balancing washers are found under the screws attaching the lead weight, the lead weight (3) may be filed to remove the necessary amount. Recheck the balance about both planes after balancing is completed.

(26) INSTALL POTENTIOMETERS.

(See figure 164.)

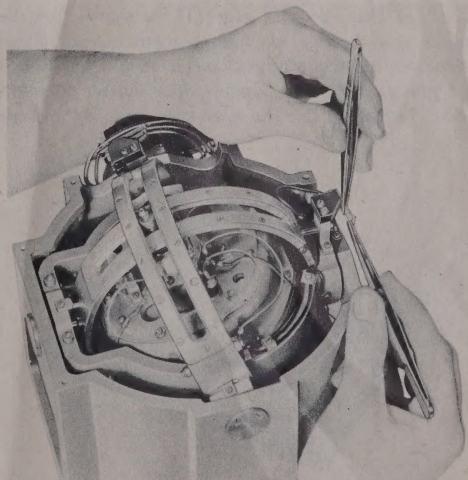


Figure 225 — Adjusting Wiper Blade Tension

Section IV Paragraph 2

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(a) Make sure that the single (elevator) potentiometer (3) is properly secured to the mounting plate assembly (5) by means of three 4-40x7/16-inch round- or fillister-head screws (1) with internal tooth lock washers (2). Put the single potentiometer assembly in place on the housing, and fasten with two 6-32x 3/8-inch binder head screws (4) and plain washers.

(b) Secure the triple potentiometer (11) to the terminal panel assembly (9) by means of three 4-40x 3/8-inch fillister- or roundhead screws (13) with internal tooth lock washers (12). Fasten the two contact assemblies (14 and 15) to the potentiometer with four 2-56x1/8-inch screws. Fasten the triple potentiometer in place, using two 6-32x1/2-inch binding head screws (10).

(c) Secure the two yellow leads (8) from the single potentiometer to the mounting plate assembly (5) with the clamp (7) and fillister-head screw (6). Insert these wires across the inside corner of the housing under the wire clip (6, figure 183), which is held in place by a 4-40x1/4-inch fillister-head screw.

(d) Connect all leads to the triple potentiometer in accordance with the wiring diagram shown in figure 223, being sure to check out each wire against the lettered prong of the AN receptacle, as indicated. In checking these leads for continuity, do not check merely to the point of connection, but check all the way from the prong in the AN connector to the final point of contact. Check all wiring leads at this time with an ohmmeter to make sure that continuity is correct.

(27) SET THE SPRING TENSION ON WIPERS. (See figure 224.)

(a) Using a gram gage (1), as shown, test the tension of each wiper on both potentiometers. Wiper tension on the triple potentiometer should be from 5 to 7 grams, and on the single potentiometer 10 to 14 grams. In making this check, be sure to hold the blade

of the gram gage parallel to the potentiometer winding so that a direct force is recorded, and connect an ohmmeter (2) between the potentiometer winding and wiper. The break in contact will then be indicated by the ohmmeter needle.

(b) If tension on wipers is not within the limits prescribed above, tension may be increased or decreased by bending the wiper slightly, as shown in figure 225.

(28) CENTER POTENTIOMETER ELEC- TRICALLY.

(a) (See figure 226.) Using master level, level up the leveling plate by means of the three adjusting screws until it is exactly level. Since the master level has two vials (one in each direction) it is important that both leveling vials be centered exactly. After leveling, remove the master level; place gyro on the leveling plate. Place the rotor spindle in a vertical position by centering the bubbles in the level vials on top of the rotor housing.

(b) (See figure 227.) Be sure that the rotor remains in this level position while making the following adjustments to electrically center the potentiometers:

1. Using an ohmmeter (4), check the resistance from one end (1) to the other end (2) of the single (elevator) potentiometer. Divide this resistance by 2; then check the resistance from one end of the potentiometer (1) to the single wiper terminal (3). If these two amounts do not agree, the potentiometer is not electrically centered, but may be adjusted by loosening the two binding head screws (5) which secure it to the gyro housing, and rotating it in the proper direc-

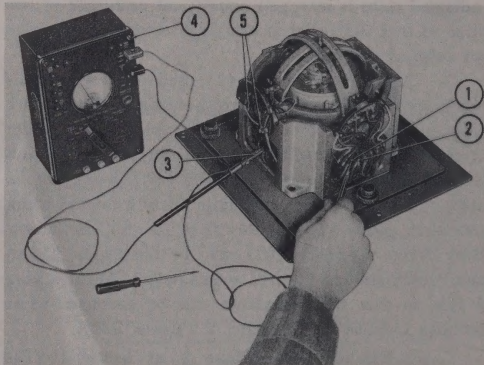


Figure 227 — Checking Centering Single Potentiometer

Index No.	Nomenclature
1.	Potentiometer End Terminal
2.	Potentiometer End Terminal
3.	Wiper Terminal
4.	Ohmmeter
5.	Binding-Head Screws

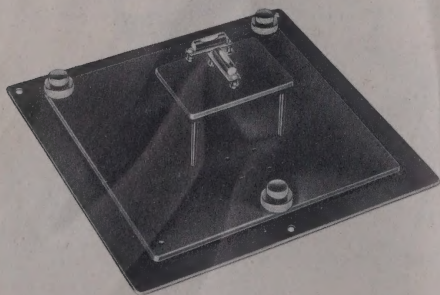


Figure 226 — Leveling Level Plate With Master Level Gage

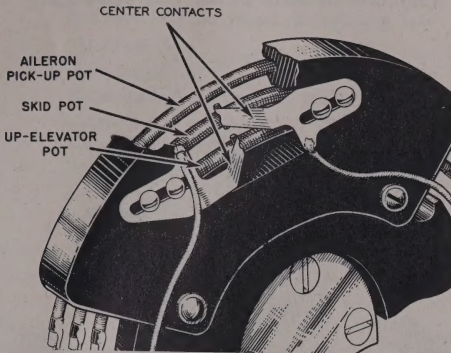


Figure 228 — Triple Potentiometer Showing Contact Assemblies

tion. When the potentiometer is properly centered, ohmmeter readings taken from either end to the single wiper will be the same. (A variation of only ± 0.4 percent of total potentiometer resistance is allowable.) Correct resistance values and permissible tolerances are given in the table of resistance values, figure 142A. Potentiometers are designated R1, R2, R3, R4 in the table. If resistance of any potentiometer is found to be outside of the limits prescribed in the table, replace the potentiometer.

2. Using the same procedure as in electrically centering the single potentiometer described above, electrically center the center (skid) potentiometer on the triple potentiometer assembly. Adjustment is made in the same manner by loosening the two binding head screws which secure the potentiometer to the housing, and rotating the potentiometer until ohmmeter readings taken from each end to the center (skid) potentiometer wiper are the same. (A variation of only ± 0.4 percent of total potentiometer resistance is allowable.)

3. After electrically centering the center (skid) potentiometer on the triple potentiometer assembly, check the top and bottom potentiometers to make sure that they are electrically centered. If readings taken from each end of each potentiometer to the wiper are not the same, it indicates that the top or bottom wiper (whichever is being tested) is not properly centered on its potentiometer. (A variation of ± 1.4 percent of the total potentiometer resistance is allowable.) This may be corrected by slightly changing the contour of the wiper blade. However, if any correction at this point is made, it will be necessary to go back and recheck the wiper tension with the gram gage, as outlined above.

4. (See figure 164.) Make sure that the rotor case is still exactly level. Set the center contact assemblies (14 and 15) on the two bottom potentiometers of

the triple potentiometer assembly exactly opposite their respective wipers (figure 228). This is done by loosening the two screws which secure them to the potentiometer. With the ohmmeter connected between the wiper and the center tap connection, slide the center tap back and forth until the point of minimum resistance is obtained. At this point, the contact assembly will be exactly opposite the wiper. Tighten the two adjusting screws and recheck to make sure that the tap has not moved in tightening. Follow this procedure for both contact assemblies. Also make sure that they make firm contact with the potentiometer winding.

5. (See figure 229.) Check all four potentiometers for shorted turns and cleanliness. This is done by connecting the ohmmeter between one end of the potentiometer and the wiper, and by moving the wiper over the entire arc of contact. Movement must be slow and uniform from one end of the potentiometer to the other. As the wiper moves across the potentiometer, watch the ohmmeter needle carefully. Any fluctuation of the ohmmeter needle indicates dirt on the potentiometer windings. Such dirt may usually be removed by merely wiping the potentiometer with a dry, lint-free cloth, although, in some cases, it may be necessary to moisten the cloth with alcohol. If alcohol is not available, carbon tetrachloride may be used. Always finish cleaning with a dry, lint-free cloth. Shorted turns are indicated by a hesitation of the needle as the wiper moves across the potentiometer. More than four consecutive shorted turns in any $\frac{1}{4}$ -inch of travel of the wiper over the potentiometer will not give satisfactory operation, and the potentiometer should be replaced. Extreme care must be used in making this check so that

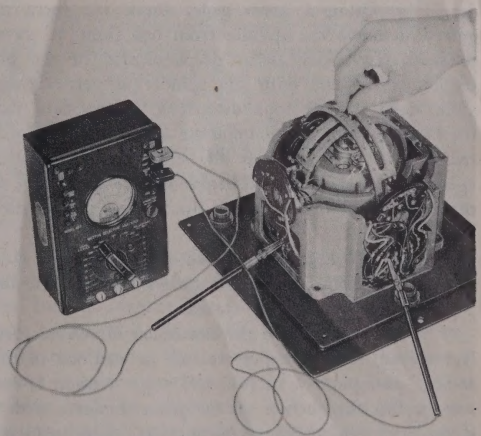


Figure 229 — Checking Potentiometers for Shorted Turns

each hesitation of the needle as it moves across the scale may be noted.

(29) RECHECK ALL FLEX LEADS, AND
RESHAPE IF NECESSARY.

(a) Check all flex leads by moving the gyro rotor spindle to the limits of its travel and observing the action of the flex leads. Flex leads should touch nothing throughout the limit of the motion, and there should be no sharp curves or kinks in the leads.

(b) Reshape flex leads where necessary.

(30) CHECK RESISTANCE TO SPINDLE
TRAVEL. (See figure 230.)

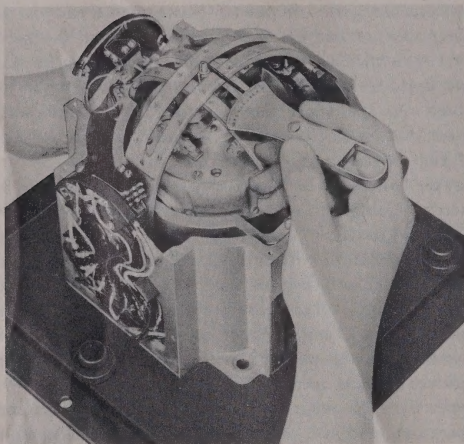


Figure 230 — Checking Friction Drag on Spindle

(a) Using a gram gage, check the force required to move the spindle from one limit of travel to the other along paths perpendicular to the potentiometer. Start with the spindle at vertical, and gram down in all four directions, taking care that the bail does not rub the spindle and cause additional friction. Always see that the other bail has fallen against the spindle before beginning the gramming so that the weight of the bail is not adding to the gram loading.

(b) Maximum allowable force required is 4 grams for the first 20 degrees each side of center, and 7 grams for remainder of travel.

(c) If more than the maximum allowable force is required, recheck wiper tension, as outlined in this section, paragraph 2, e, (27). If wiper tension is correct, polish the surface of the potentiometers with a clean, dry cloth to reduce friction drag, and again test with gram gage. If friction is still too great it will be necessary to recheck the bearings. Refer to this section, paragraph 2, d, (1).

(31) CHECK BAIL FALL. (See figure 231.)

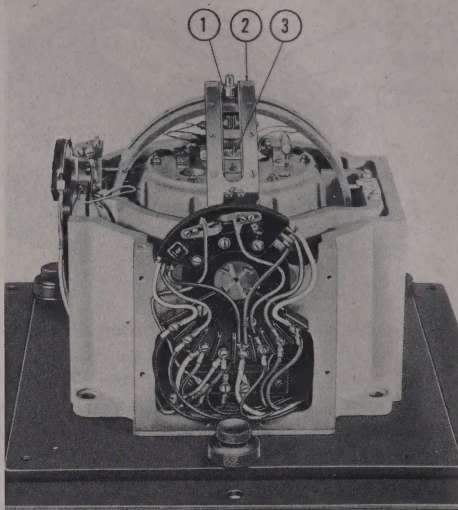


Figure 231 — Testing Bail Fall

Index No. Nomenclature

- | | |
|----|--------|
| 1. | Roller |
| 2. | Bail |
| 3. | Bubble |

(a) The action of the erecting bails is very important to the operation of the gyro, because it is these bails which keep the gyro in the correct position by falling against the rotating erecting rollers whenever the gyro spindle moves away from a vertical position. It is very important, therefore, that the bail assemblies be properly balanced and that the bushings be as free from friction as possible, so that the bail will fall against the roller before the spindle moves as much as 0.7 degree from the exact center position in any direction.

(b) Because the gyro spindle is exactly centered *only* when the gyro is at operating temperature, the gyro must be at operating temperature when checking bail fall. Connect a 26-volt dc source to the M-prong of the AN connector and to the ground strap of the gyro. Allow gyro to warm up for at least 1 hour before checking bail fall.

CAUTION

A few gyros are designed to operate on 13 volts dc instead of 26 volts dc. Make sure of voltage as follows:

26-volt units:

Red leads to motor field coils.

Housing stamped "26 V," or AN recep-

tacle painted red.

Red dot may be found on erecting cut-out magnet.

13-volt units:

Black leads to motor field coils.

Housing may be stamped "13 V."

No color on AN receptacle.

Blue dot may be found on erecting cut-out magnet.

(c) With the gyro running, the spindle may be precessed in any direction by applying a slight pressure to the spindle in a direction at 90 degrees to the direction in which the motion of the spindle is desired. First, precess the gyro spindle at right angles to the top bail by pressing in a direction along the line of the top bail. By pressing first to one side and then on the other (figure 231), the gyro spindle may be made to move from one side to the other so that the bail fall in either direction may be observed. Apply only a slight force so that the gyro spindle moves very slowly. The moment that the bail (2) falls against the roller (1), note the position of the bubble (3) on the level vial located under the bail being tested. When the bail falls, the level vial bubble should not read more than 0.7 degree on either side of center. (Each division on level vial indicates 1 degree.) A reading greater than this amount on either side indicates one or more of the following troubles:

1. Dirty or gummy bail bushings cause friction which may prevent the bail from falling properly. Remove the bail and the bail bushings; clean, as outlined in this section, paragraph 2, d. Replace bail bushings; again test for bail fall.

2. The top bail may fall incorrectly because of a slight bend in the retaining lug, which causes the bail to ride on the retaining lug rather than on the bail bushings. This may be checked by turning the retaining lug out of the slot in the bail and again checking the bail fall. This condition should then be corrected.

3. Incorrect alignment of the spindle will cause improper bail fall. Usually, if this is the case, the point at which the bail falls on one side will be several tenths of a degree more than on the other side. Improper bottom bail fall, due to improper alignment, may result if the test is made when the gyro is not at operating temperature, or if some error was made in aligning the rotor spindle, or if the locked bearing is not tightly locked. (Refer to this section, paragraph 2, e, (14).)

4. Bail fall of the top bail may be incorrect because of an excess of end play between the cardan and the housing. When the top bail does not fall correctly, be sure to measure the end play between the cardan and the housing; also make a bail fall test with

the cardan pushed to the limit of its end play in each direction to determine whether or not this end play was causing faulty bail fall.

5. Improper balance of the bail itself will also cause faulty bail fall. *If all causes of faulty bail fall listed above have been checked, and it has been determined that the rotor case is properly centered in the cardan, it can reasonably be assumed that improper balance of the bail is causing improper bail fall.* Weights may then be removed from one side of the bail and added to the other side until the proper bail fall is obtained. However, be sure that the same amount of weight is subtracted from one side as is added to the other, or top and bottom heaviness of the counterbalance guide channel and top bail, or cardan and bottom bail, will be affected and cause improper balance of the gyro assembly.

(32) CHECK THE OPERATION OF THE
ERECTING CUT-OUT MECHANISM.

(See figure 199.)

- (a) After the check for bail fall is made, and before turning off the current, touch a wire between the M-prong and the N-prong on the AN connector. Observe the operation of the erecting gear and roller.

- (b) When the connection is made, the erecting cut-out gear should drop, and the top roller stop rotating. As soon as the connection is broken, the gear should return to its upper position and engage the top roller, which again should begin to rotate.

- (c) Reduce the power source to 15 volts; again check it in the same manner. If the gear does not disengage properly from the roller, recheck the clearance and adjustments outlined in this section, paragraph 2, e, (9).

- (d) If the erecting cut-out armature does not move, connect a voltmeter to the terminal on the erecting cut-out magnet, and check to make sure that current is reaching the magnet. If it is reaching the magnet, but the magnet is not energized, the small lug on the end of the magnet wire which connects to the terminal screw has probably been twisted enough to break the wire. Remove the terminal screw, and check this connection.

- (e) If the magnet energizes properly, but the armature does not move, the air gap between the armature and the magnet base is probably too great. This may be adjusted by bending out the armature stop which rests against the frame assembly so that the armature is moved in closer to the magnet base. After making such an adjustment, the fingers under the erecting cut-out gear must be readjusted to provide proper engagement of the dogs which drive the upper roller. These should be readjusted, as outlined in this section, paragraph 2, e, (9).

(33) CHECK SPEED OF ROTOR.

(a) When operating properly, the gyro rotor will turn between 6500 and 8000 rpm. The gear reduction to the bronze intermediate gear is 5-2/3 to 1; or, if the rotor is turning at 7000 rpm, the bronze intermediate gear will turn at 1235 rpm. The gear reduction to the roller gear is 32 to 1; therefore, when the rotor is turning at 7000 rpm, the roller gear will turn at 219 rpm.

(b) Using a Strobotac tachometer, check the speed of the bronze intermediate gear, or the roller gear, by placing a pencil mark on the gear and adjusting the Strobotac until this mark appears stationary and there is only one image.

(c) When the gyro will not come up to speed, see trouble shooting chart, this section, paragraph 2, f, for the cause. Check, as outlined in this trouble shooting chart, until the cause has been determined and corrected, as indicated.

(d) Using an ammeter, check the current consumption during this speed test. On 26-volt gyros, current consumption should not exceed the following limits: Starting current—3.5 amperes; current 10 seconds from start—2.0 amperes; full speed current—.64 ampere. Current consumption on 13-volt gyros should not exceed the following limits: Starting current—.65 amperes; after 10 seconds from start—.425 amperes; at full speed—.15 amperes. (See CAUTION note this section, paragraph 2, e, (22) to determine the difference in markings of 26-volt gyros and 13-volt gyros.)

(34) INSTALL ALL COVER PLATES.

(See figure 162.)

(a) Install potentiometer cover plates (15), using six 6-32x1 1/8-inch, fillister-head screws (14). Make sure that gaskets (16) under these covers are in good condition and properly in place. Before tightening these screws, line up the top of the cover plate with the top of the rotor housing so that the top cover gasket (10) will seat firmly against both the gyro housing and the potentiometer cover plates (15).

(b) Install the identification plate (12), using four 3-48x1 1/4-inch, fillister-head screws (11). Make sure that the gasket (13) under this plate is in good condition and properly in place.

(c) Install bottom cover plate (18), using four 3-48x5/16-inch fillister-head screws (19), again making sure that the gasket (17) is in place and is in good condition.

(d) Install the gyro housing cover (9), taking particular care to see that the gasket (10) is properly in place. If the shipping cover (4) was in place on the gyro housing cover, remove this shipping cover; replace the window (3) on top of the housing cover, using the two fillister-head screws provided (2). Secure the gyro housing cover in place, using the six 6-32x

11/16-inch, fillister-head screws (1). Note that two of these screws have drilled heads and that these screws should be installed together so that the unit may be resealed.

(e) Install the ground lead cable (21), using an 8-32x1 1/4-inch, fillister-head screw (22), with a spring lock washer (23) under the head of the screw.

(35) FINAL CHECK FOR SPINDLE TRAVEL.

(See figure 232.)

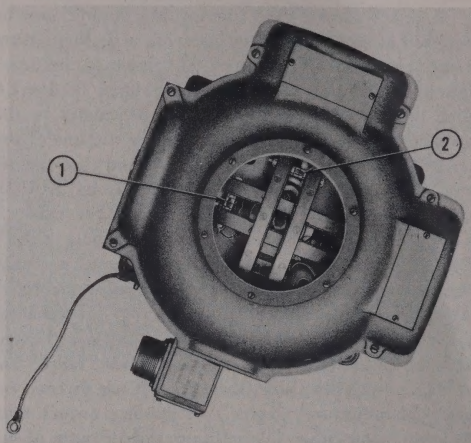


Figure 232 — Test for Bubble Travel

Index No. Nomenclature

- | | |
|----|------------|
| 1. | Level Vial |
| 2. | Level Vial |

(a) Connect the positive terminal of a 26-volt dc power supply to the M-prong of the AN connector and the negative to the ground terminal. Allow the gyro motor to operate for approximately 1 hour so that gyro will be at operating temperature.

CAUTION

A few gyros are designed to operate on 13 volts dc instead of 26 volts dc. Make sure of voltage as follows:

26-volt units:

Red leads to motor field coils.

Housing stamped "26 V," or AN receptacle painted red.

Red dot may be found on erecting cut-out magnet.

13-volt units:

Black leads to motor field coils.

Housing may be stamped "13 V."

No color on AN receptacle.

Blue dot may be found on erecting cut-out magnet.

(b) Watching the level vials (1 and 2) on top of the rotor case through the window, observe the bubble travel through one complete cycle of rotation. Record the maximum position of each bubble on each side of the center mark.

(c) The total travel of either bubble should not exceed 1.4 degrees from one side to the other. (Each division on the level vial indicates 1 degree.)

(d) The center point of this bubble travel must not lie more than $\frac{1}{2}$ of one degree either side of center. This point is easily determined by taking the number of degrees of bubble travel each side of center, subtracting the smaller amount from the larger, and dividing by 2. This will give the center of bubble travel in degrees from the exact center.

(e) Any gyro which does not fall within these limits (1.4 degrees maximum bubble travel, center point of bubble travel not more than $\frac{1}{2}$ of 1 degree either side of center) is not satisfactory for service. When bubble travel fails to meet these specifications, it will be due to one or more of the following causes:

1. LEVEL VIALS NOT PROPERLY SET.—

If level vials are not adjusted to the correct position, the center point of bubble travel will not be within the prescribed limits. Check and reset if necessary. (Refer to this section, paragraph 2, e, (18).)

2. IMPROPER BALANCE.—If gyro is not properly balanced, the center point of bubble travel will not be within the prescribed limits. If balance is incorrect, rebalance in accordance with this section, paragraph 2, e, (22), (23) and (25).

3. GUIDE ROLLER STICKING.—If the guide roller is sticking in the counterbalance guide channel, the center point of bubble travel will be outside of the prescribed limits. Check to make sure that no sticking occurs.

4. FRICTION IN BEARINGS OR POTENTIOMETERS.—If too much friction is present in the bearings, or potentiometers, the total bubble travel will exceed the prescribed limits. This frictional force, applied to the gyro, causes it to precess and prevents it from staying erect.

a. Check for friction in potentiometers, first using a gram gage (as described in this section, paragraph 2, e, (30)) to check the tension of the wipers on the potentiometers. Make any necessary adjustments. Use a gram gage to check the force required to move the spindle through its entire arc, starting with the spindle vertical and moving it down in all four directions. This should not exceed 4 grams for the first 20 degrees of travel. If force required exceeds this limit, take a dry cloth and polish the surface of the potentiometers to reduce the friction between the potentiometers and wipers. If, after rechecking, the over-all bubble travel is still beyond the prescribed

limits, remove both potentiometers and again check bubble travel. If the potentiometers were at fault, the excess bubble travel will have now been corrected. If cleaning the potentiometers and adjusting wipers will not eliminate the unnecessary friction, remove the potentiometers. If bubble travel still exceeds limits with potentiometers removed, bearing friction is the probable cause. If bubble travel is now within the prescribed limits, put on new potentiometer and recheck.

b. In the case of bearing friction, it will be necessary to remove the bearings and clean them thoroughly again, as indicated in this section, paragraph 2, d, (2). Poor bearings in Axis 1 (roll axis, figure 155) will cause travel in Axis 2 (pitch axis). Bad bearings in Axis 2 will cause travel in Axis 1. Check bearing fit into sockets and on gudgeon pins. Too tight a fit will cause distortion of bearing races, and friction will result.

(36) FINAL CHECK FOR ERECTION TIME.
(See figure 233.)

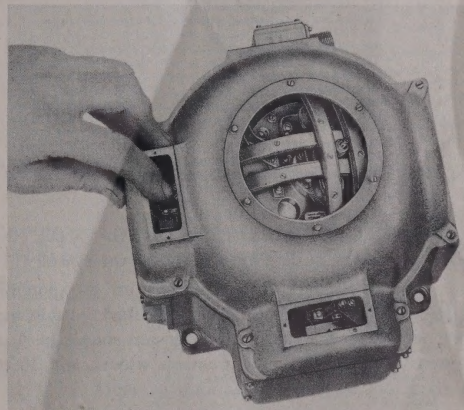


Figure 233 — Precessing Gyro by Hand

(a) Remove the two fillister-head screws which secure the potentiometer inspection covers to the housing cover assembly; remove the inspection covers and gaskets. This will uncover the potentiometer wiper block so that a force may be applied to either wiper block with the finger, thus causing the gyro to precess at 90 degrees to the force applied and in the direction of rotation.

(b) With the gyro at operating speed and temperature, precess the gyro with the finger (figure 233) to the extreme limit in all four quadrants midway between the axes. Check the time required for the gyro to erect to within 1 degree of vertical, as indicated by the level vials on top of the rotor case. This time must

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not exceed 12 minutes for any one of the four quadrants.

(c) If the erection from any one quadrant (*figure 234*) exceeds 12 minutes, one or more of the following may be the cause:

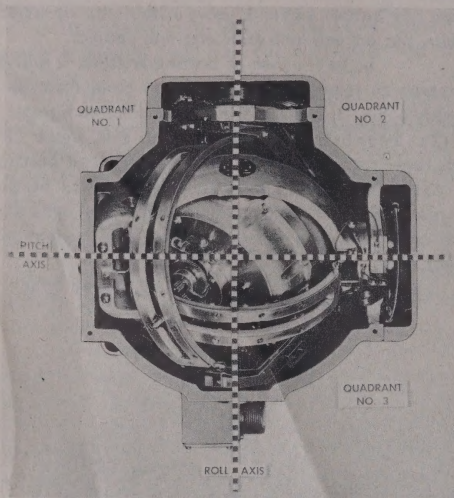


Figure 234 — Gyro Tilted to Quadrant No. 4

1. **POTENTIOMETER DRAG.**—Make the following checks to determine if this is the cause:

a. Recheck wiper tension on the potentiometers, using a gram gage, as described in this section, paragraph 2, *e*, (27). This tension should be 5 to 7 grams on the triple potentiometer wipers, and 10 to 14 grams on the single potentiometer wiper.

b. Polish the potentiometer windings and the wiper contacts with a piece of clean, lint-free cloth.

c. Examine potentiometer windings carefully for nicks, or uneven spacing of windings.

2. **BAD BEARINGS.**—Disassemble and recheck bearings for dirt, or any roughness, and recheck the bearing fit into the bearing socket, or bearing bore, and onto the gudgeon pin. Make certain that rotor case bearing sockets are not distorting the outer bearing race.

3. **POOR FRICTION OF ROLLER ON CORK.**—Clean the bail corks with alcohol, or carbon tetrachloride (U. S. Army Specification No. 4-503-110B). Check bail corks also for rough spots.

4. **UNBALANCE OF GYRO.**—Remove potentiometer mounting screws; move the potentiometers away from the housing until the wipers do not contact

the windings. Recheck the static balance of the gyro, as outlined in this section, paragraph 2, *e*, (22), (23), and (25).

5. **GUIDE CHANNEL ROLLER BINDS IN CHANNEL.**—Recheck the force necessary to move the gyro spindle from one limit of travel to the other, as described in this section, paragraph 2, *e*, (30). Watch closely for any variation in the gram gage reading that might indicate bad bearings, or a point where the guide roller binds in the guide channel.

(37) INSERT RUBBER GROMMET, AND INSTALL SHIPPING COVER.

(a) Using a loop of wire (1, *figure 235*) through the holes in the housing, provided for the rubber mounting grommet, pull each of the four rubber mounting grommets (2) into place.

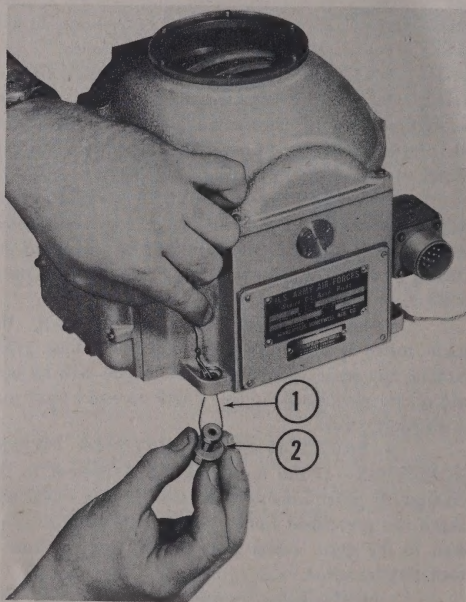


Figure 235 — Inserting Rubber Grommet

Index No.	Nomenclature
1.	Wire Loop
2.	Rubber Grommet

(b) Remove the window (3, *figure 162*); install the shipping cover assembly (4) on top of the gyro housing cover assembly. Use extreme care to be sure that the rotor spindle enters the rubber grommet in the shipping cover. Secure the window and the shipping cover in place with the six fillister-head screws (2) which were used to secure the window in place.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
CENTER POINT OF BUBBLE TRAVEL IS MORE THAN 1/2 DEGREE FROM VERTICAL.	Level vials not correctly leveled.	Reset level vials. (Refer to this section, paragraph 2, e, (18).)
	Unbalanced gyro.	Rebalance gyro, as described in this section, paragraph 2, e, (22), (23), and (25).
	Gyro axes not in alignment.	Align gyro axes. (Refer to this section, paragraph 2, e, (20) and (21).)
	Erecting bail falls sooner to one side than to the other.	Check alignment of axes. If correct, balance erecting bail.
	Guide channel roller binds in counterbalance guide channel.	Polish out any nicks in the channel; remove the aluminum that may have built up on the roller with 0000 polishing paper.
STATIC BALANCE OF GYRO SHIFTS.	The locked bearing is not locked securely in the rotor case.	Tighten the locked bearing lock-in screws. If static balance still shifts after tightening the locking screw, it will be necessary to reshim under the locked bearing as described in this section, paragraph 2, e, (20).
ERECTING CUT-OUT DOES NOT OPERATE.	Faulty lead wire connections, or burned out flex lead.	Check continuity from N-prong of AN receptacle to erecting cut-out magnet. If open, repair.
	End of fine magnet winding wire broken loose from lug.	Repair.
	Gap between erecting cut-out armature and erecting cut-out magnet base too large.	Adjust by bending stop on erecting cut-out armature assembly to strike erecting cut-out frame sooner. Then readjust actuating arms.
	Armature out of alignment so that gap is too small and residual magnetism overcomes spring tension.	Line up armature.
	Erecting cut-out magnet coil open.	Replace.
	Spindle rusted so that erecting cut-out roller gear will not move up and down on spindle.	Clean and polish until a free fit of roller gear on spindle is obtained. Recoil.
	Upper roller is engaged.	Bend actuating arms so that the lugs on the top and bottom rollers clear each other by .002 inch (min.) when the erecting cut-out is energized.

Trouble	Probable Cause	Remedy
INTERMITTENT SIGNAL FROM POTENTIOMETERS.	Dirty potentiometer.	Check tension of wipers on potentiometers. Clean potentiometers with a dry, lint-free cloth. If unable to remove dirt with a dry cloth, dampen cloth with alcohol or carbon tetrachloride. Repolish potentiometers with a dry, lint-free cloth.
	Faulty lead wire connections or flex lead.	Check from wiper to respective AN connector prong; if faulty, repair. Check for grounds between lead wires, or flex lead and ground. If grounds are apparent, replace the faulty part.
SIGNAL IS OBTAINED FROM POTENTIOMETER WHEN GYRO IS AT ITS MECHANICAL CENTER.	Potentiometers are not properly centered.	Refer to this section, paragraph 2, e, (28), for procedure in centering potentiometer.
	Contact and wiper blade both touch potentiometer winding, due to improper forming of wiper blade.	Change the contour of the wiper blade.

3. DIRECTIONAL STABILIZER.

a. GENERAL.—Refer to this section, paragraph 2, *a*. All of the general information regarding bearings and balance for the vertical flight gyro applies to the directional stabilizer, except that in regard to static balance, only the balance of the rotor and case assembly in the cardan applies. Therefore, there is only *one axis* about which static balance must be established, and this is the axis through the center of the rotor case bearings. Static balance about this axis is determined in exactly the same way as in the vertical flight gyro, as outlined in this section, paragraph 2, *a*, (2), (*b*). (See figures 154 and 155.) Dynamic balancing of the rotating weight of the stabilizer rotor is accomplished in exactly the same way as on the vertical flight gyro and is done in the dynamic balancing machine shown in figure 156, or a similar machine.

b. OVERHAUL TOOLS REQUIRED.

(1) The following special tools should be available for use in disassembly, inspection, repair, and reassembly of the directional stabilizer, in addition to an assortment of standard tools, such as screw drivers, plier, wrenches, etc.

(2) SPECIAL TOOLS. (See figure 236.)

Nomenclature	Application
Clutch Drum Puller	To remove clutch drum from upper gudgeon pin.
Rotor Case Stand	To support rotor and case assembly.
Spreaders	For separating halves of rotor case.
Ohmmeter	For testing.
0-50 Pound Spring Balance	For testing torque motor and clutch assembly.
Torque Motor Test Arm	For testing pull of torque motor.
0-16 Ounce Spring Balance	Motor brushes.
Thickness Gage	For bearing adjustments.
Taper Gage	For checking end play.
Seating Pins	To reseal rotor bearings.
0-10 Gram Gage	Adjusting wiper tension.
0-50 Gram Gage	Checking drag on rotor.
0-150 Gram Gage	Checking friction drag.
Strobotac	Checking rpm of rotor.

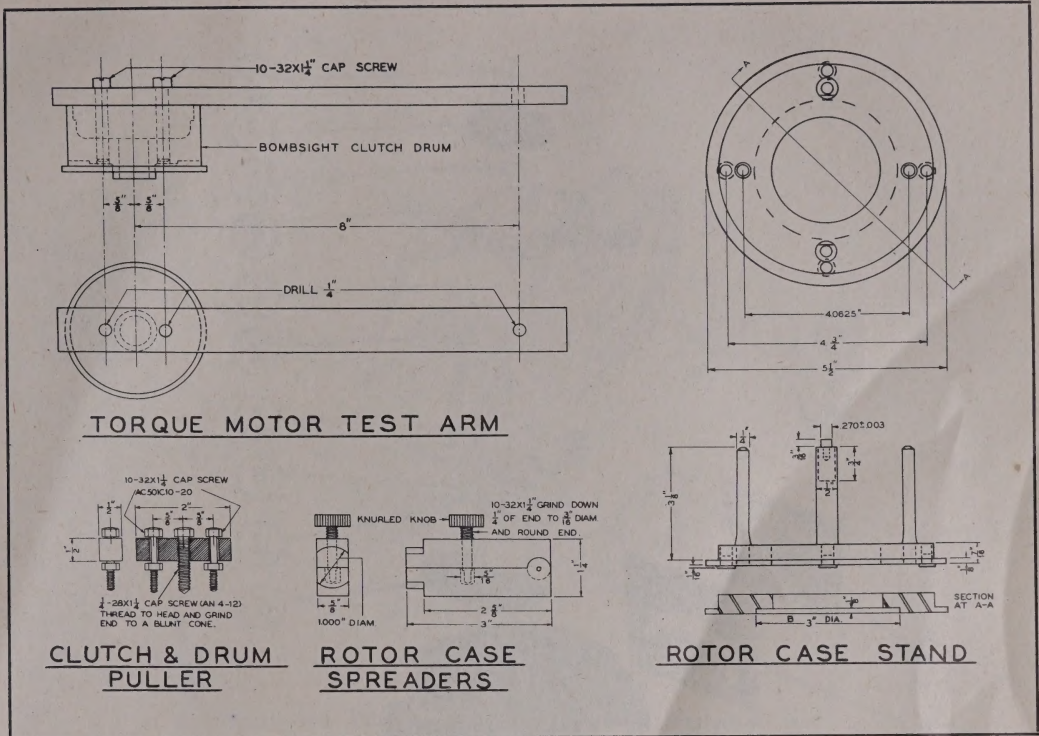


Figure 236 — Special Tools, Stabilizer

c. DISASSEMBLY.

CAUTION

Do not remove any of the balance screws or weights from the rotor case in disassembly. These weights and screws serve only to give proper static balance to the rotor and case assembly, as explained in this section, paragraph 2, e, (18). Their removal in overhauling the stabilizer will only make static balance more difficult.

Note

Place all parts in marked sections of a tray similar to the one shown in figure 161 so that parts may be easily identified at any time.

(1) REMOVE COVERS AND CLUTCHES.

(See figure 237.)

(a) Remove the four fillister-head screws (3) attaching the name place cover (2) to the stabilizer housing; remove the name plate cover and also the shipping plate (1), which may be found in place beneath the name plate cover. Two snap fasteners (4) will be found under the two top screws.

(b) Remove the four fillister-head screws (16) and lock washers (15) attaching the torque motor cover (14) to the housing, and remove this cover.

(c) Remove the fillister-head screw (5) holding the bombsight clutch cover plate (6) in place, and remove the cover plate.

(d) Slip the bombsight clutch assembly (8) from the clutch drum, and remove the assembly.

(e) Remove the two cotter pins from the connecting rod studs at either end of the autopilot clutch connecting rod, and remove the special flat washers (9) under the cotter pins. Lift the connecting rod (10) off the studs carefully, making sure to lift it from both studs at the same time to prevent bending of the arms, or studs, which may cause binding when the unit is re-assembled.

(f) Remove the large hex nut (7) that secures the autopilot clutch and drum assembly (11) to the upper cardan gudgeon pin. If the stabilizer is fitted with a bombardier's turn control, it is necessary to remove the shoulder stop screw which attaches the turn control arm to the autopilot clutch lock strip. This

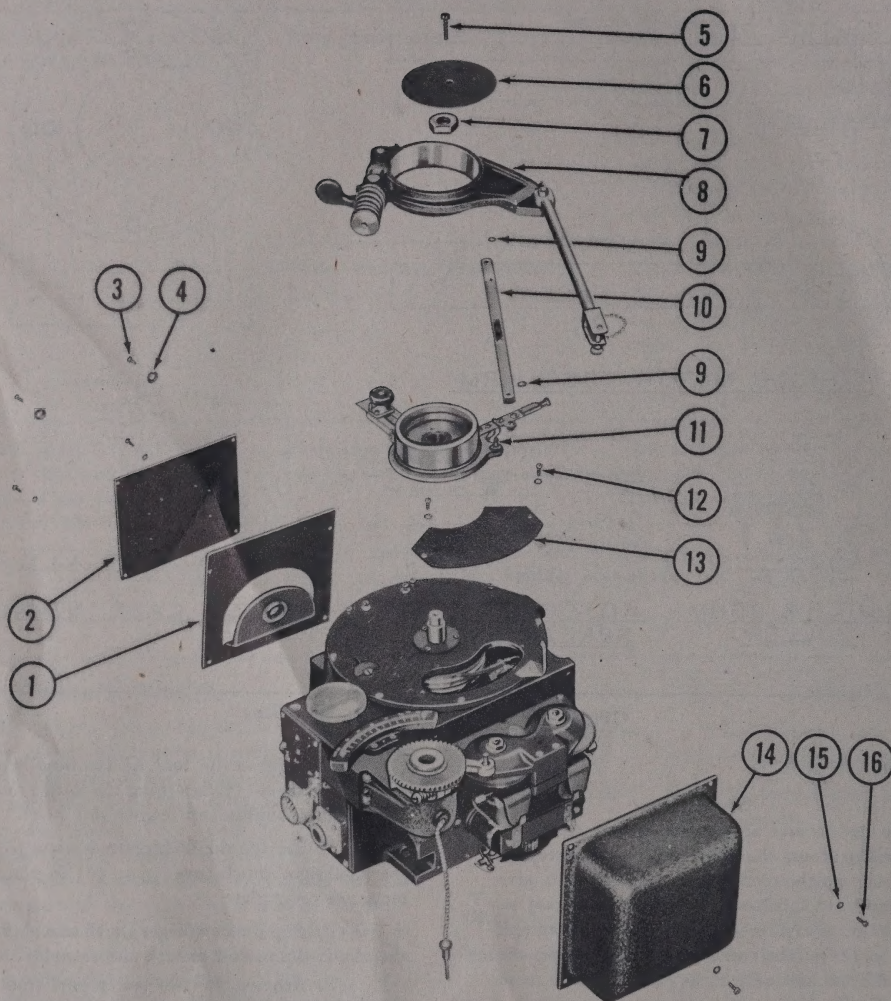


Figure 237 — Autopilot Clutch, Bombsight Clutch, and Cover, Removed

Index No.	Nomenclature	Index No.	Nomenclature	Index No.	Nomenclature
1.	Shipping Plate	7.	Hex Nut	13.	Cover Inspection Plate
2.	Name Plate Cover	8.	Bombsight Clutch Assembly	14.	Torque Motor Cover
3.	Screws	9.	Washers	15.	Washers
4.	Snap Fasteners	10.	Connecting Rod	16.	Screws
5.	Screw	11.	Autopilot Clutch and Drum Assembly		
6.	Cover Plate	12.	Screws		

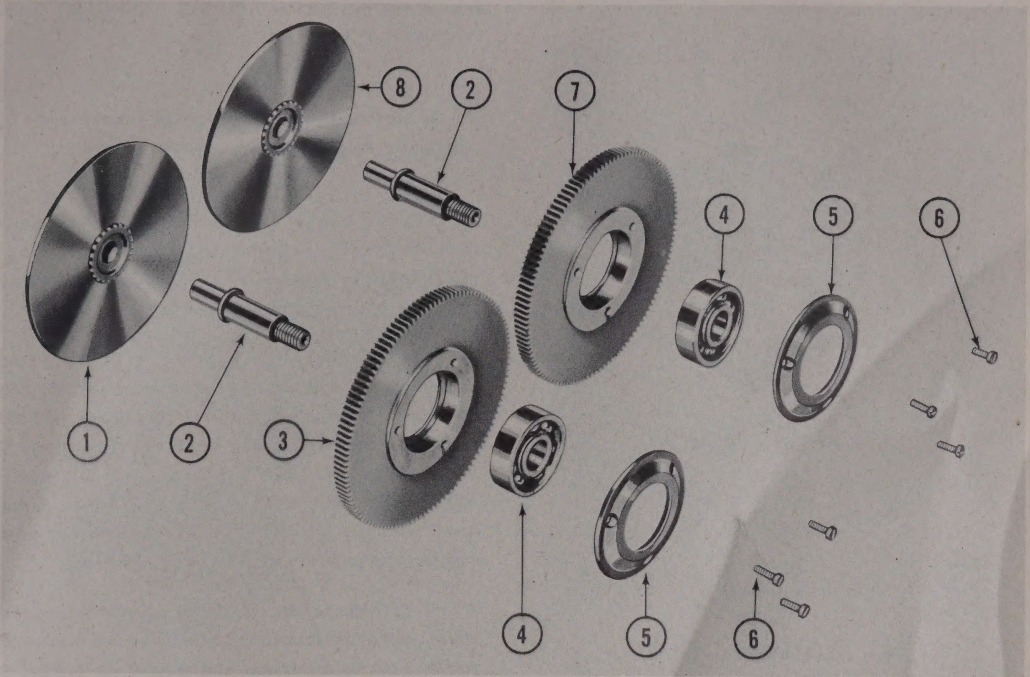


Figure 244 — Clutch and Gear Assemblies, Exploded View

Index No.	Nomenclature	Index No.	Nomenclature
1.	Clutch and Pinion Assembly	5.	Bearing Retainers
2.	Stud Shaft	6.	Screws
3.	Gear Assembly—Bronze	7.	Gear Assembly—Steel
4.	Bearings	8.	Clutch and Pinion Assembly

bly it remained with while the two were separated. The gear assembly turns in one ball bearing in the plate assembly, and one in the torque motor assembly.

CAUTION

Do not attempt to disassemble cardan drive pinion and gear assembly.

(d) (See figure 244.) Lift the clutch and pinion assembly (1) from the bronze gear assembly (3), and scribe a single mark on the inside bronze hub of the clutch and pinion assembly (1). This will indicate that this particular clutch and pinion assembly is to be re-assembled to the bronze gear assembly (3). Lift the other clutch and pinion assembly (8) off the steel gear assembly (7).

CAUTION

Do not attempt to disassemble the clutch and pinion assembly. These parts are carefully fitted and pressed together and must be re-

placed as a unit if any portion of them is damaged.

(e) (See figure 243.) Using a 1/2-inch end wrench to loosen the nuts (5) securing the stud shafts to the plate assembly, remove the nuts and the flat washers (6) under them. Turn the plate over and remove the bronze gear assembly (10) and the steel gear assembly (14), together with the stud shafts on which they turn.

Note

Be sure to keep each stud shaft with the gear assembly for which it was fitted. This will simplify fitting the bearing to the stud shaft and the clutch and pinion assembly to the stud shaft in reassembly.

(f) (See figure 244.) Remove the three fillister-head screws (6) holding the clutch gear ball-bearing retainers (5) to the gear assemblies (3 and 7), and

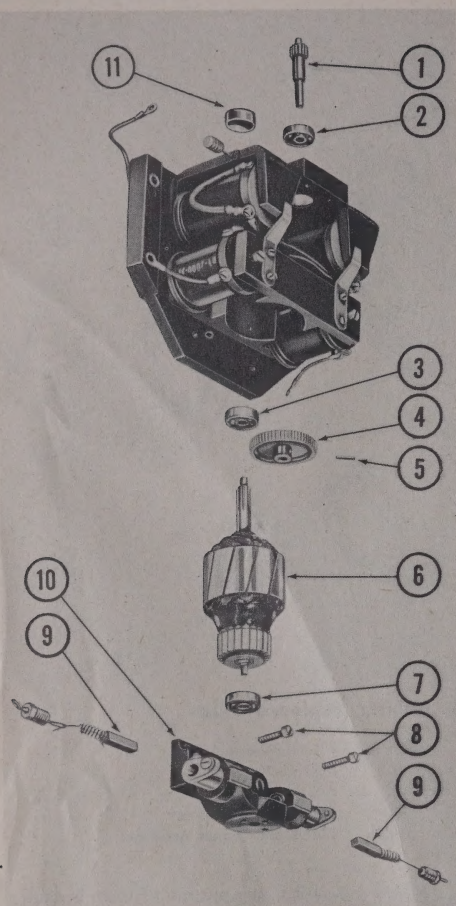


Figure 245 — Torque Motor Armature, End Bracket and Intermediate Shaft and Gears, Exploded

Index No.	Nomenclature
1.	Pinion Shaft
2.	Bearing
3.	Bearing
4.	Intermediate Gear
5.	Tapered Pin
6.	Motor Armature
7.	Bearing
8.	Screws
9.	Brush Assembly
10.	Bracket Assembly
11.	Spacer

remove the retainers and the ball bearings (4) which they secure in place.

Note

Be sure to place the bearings in covered containers properly marked for identification.

(g) (See figure 243.) Push the cardan drive pinion shaft bearing (8) and the intermediate pinion shaft ball bearing (9) out of the plate assembly, using a small drift pin through the holes provided to push against the outer race of the bearings.

(b) (See figure 245.) Disconnect the brush leads from the brush holders by removing the two binding-head screws. Use a $\frac{1}{4}$ -inch wrench to unscrew the brush adjusting plug. As the first brush assembly (9) is removed, scribe the brush holder on that side with a single mark. Also, scribe the top edge of the carbon brush with a single mark. Scribe the opposite brush and the opposite brush holder with two marks.

(i) Remove the two fillister-head screws (8) which fasten the armature commutator-end bracket assembly (10) to the frame, and remove the bracket assembly and the torque motor armature (6).

(j) Push out the armature ball bearings (3 and 7), using two small pins through the holes provided to push against the outer race of the bearings. Place the bearings in a covered container, and mark for identification. Either brush holder assembly may be removed by pushing it out of the bracket and by using a pin through the brush holder on the opposite side. However, do not remove these brush holders unless they are damaged and require replacement. The insulated brush holder is surrounded by a brush holder insulator tube which will be removed with the brush holder when it is pushed out. Brush holder assemblies should be properly identified on removal to facilitate proper replacement.

(k) (See figure 246.) Remove the four fillister-head screws (2) which secure the two clutch magnet armature spring stops (3) to the upper field frame (4) of the torque motor, and remove the armature spring stops.

(l) Remove the binding-head screw which attaches the three red leads to the right-hand field coil;

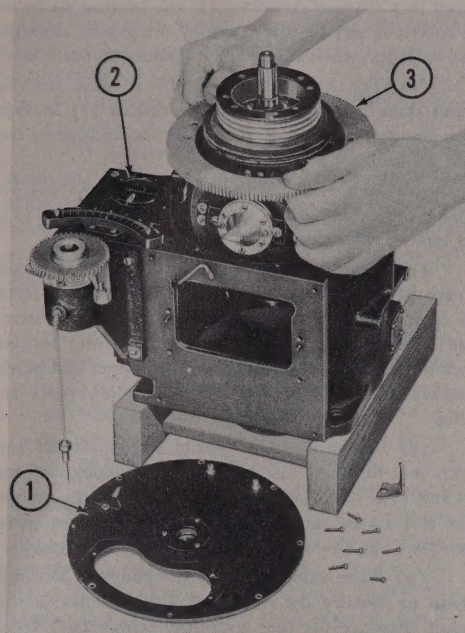


Figure 248 — Removing Rotor Case and Cardan Assembly

Index No.	Nomenclature
1.	Cover Assembly
2.	Housing
3.	Rotor Case and Cardan Assembly

(7) DISASSEMBLE HOUSING TOP COVER ASSEMBLY. (See figure 249.)

(a) Remove the three fillister-head screws (4) which fasten the dust collar (6) to the top cover (9), and remove the dust collar. Slide out the leather washer (7) from beneath the collar.

(b) If the top cardan ball bearing (10) remained in the top cover, pull the bearing out and place it in a covered container. If the bearing sticks in the top cover, it may be removed by driving on the outer race with a small pin inserted through the holes provided for the screws (4) which hold the dust collar in place.

(c) The ventilator cover (11) may be removed by simply removing the shoulder screw (12) holding it in place. The two stop screws (5) may also be removed from the top cover.

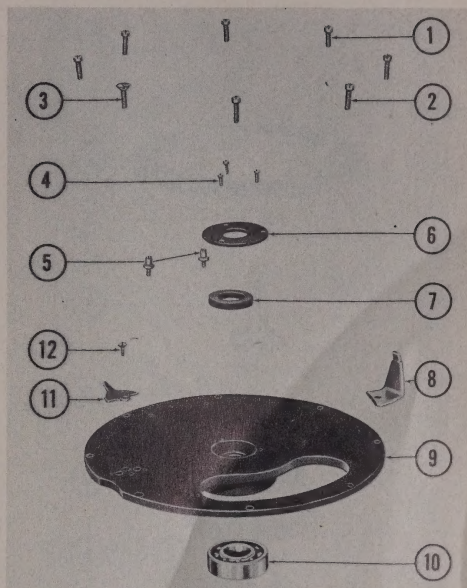


Figure 249 — Top Cover Assembly, Exploded View

Index No.	Nomenclature
1.	Screws
2.	Screw
3.	Screw
4.	Screws
5.	Stop Screws
6.	Dust Protector Washer Retainer
7.	Dust Protector Washer
8.	Course Centering Pointer
9.	Top Cover
10.	Bearing
11.	Ventilator Cover
12.	Shoulder Screw

(8) REMOVE ROTOR AND CASE ASSEMBLY FROM CARDAN ASSEMBLY.

(See figure 250.)

(a) Place the rotor on the rotor case stand. (See figure 236.)

(b) Remove the upper and lower gudgeon ball bearings, and place in covered containers. (The upper bearing may have been removed in the top housing cover.) If the lower bearing stayed in the bottom bearing socket, it should be removed from the socket and

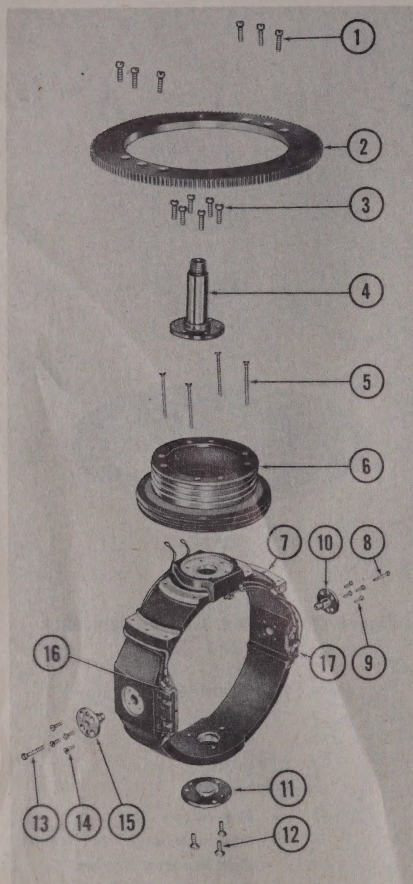


Figure 250 —Cardan Assembly, Exploded View

Index No.	Nomenclature
1.	Screws
2.	Cardan Drive Gear
3.	Screws
4.	Upper Gudgeon Pin
5.	Screws
6.	Slip Ring Assembly
7.	Cardan
8.	Locking Screw
9.	Screws
10.	Gudgeon Pin
11.	Gudgeon Pin, Lower
12.	Screws
13.	Locking Screw
14.	Screws
15.	Gudgeon Pin
16.	Contact Plate Assembly
17.	Terminal Block

placed in a covered container. If the bearing sticks in the socket, it may be driven out by using pins, through the two holes provided, to drive against the outer race.

(c) (See figure 250).—Scribe a mark on the cardan drive gear (2) and on the cardan (7) so that when the gear is removed it may be reassembled in the same position.

(d) Remove the six fillister-head screws (1) attaching the cardan drive gear (2) to the cardan (7), and remove the cardan drive gear.

(e) Remove the binding-head screws at each end of each green flex lead, and remove the flex lead from the rotor case and cardan. Remove the two fillister-head screws which attach the wiper actuating contact block to the rotor case, and remove the wiper and block assembly together with the short black lead wire attached.

(f) Loosen the two locking screws (8 and 13) which lock the rotor case bearings to the gudgeon pins (10 and 15). The locked bearing is the bearing on the same side as the torque motor actuating contact plate assembly. The free bearing is on the opposite side.

(g) Place scribe marks on the gudgeon pins and cardan to identify the pins and their position in the cardan. Remove the four oval-head screws (14) from the locked bearing gudgeon pin (15), and the four screws (9) from the free bearing gudgeon pin (10); insert two 6-32 screws through the puller holes in each gudgeon pin.

(b) Screw in on the two puller screws evenly until the gudgeon pin has pulled free of the bearing and can be lifted out. (See figures 251 and 236.)

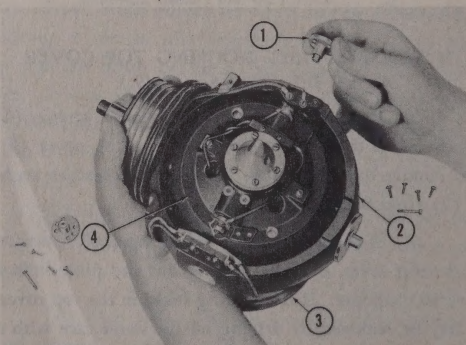


Figure 251 — Removing Cardan Assembly from Rotor and Case Assembly

Index No.	Nomenclature
1.	Gudgeon Pin
2.	Cardan
3.	Rotor Case Stand
4.	Rotor

(i) Lift the cardan carefully off the rotor case, taking care not to scratch the inside of the cardan on the fillister-head screws which hold the bearing sockets in place on the rotor case.

(9) **DISASSEMBLE CARDAN ASSEMBLY.**
(See figure 250.)

(a) Remove the four binding-head screws which attach the leads to the torque motor actuating contact plate assembly (16), and disconnect the lead from the assembly. Remove the two fillister-head screws which secure this assembly to the cardan, and remove the assembly complete.

Note

The torque motor actuating contact plate assembly, although fastened together with four fillister-head screws, must be considered an assembly and should not be disassembled. If it is damaged for any reason, it must be replaced with a complete new assembly.

(b) Remove the three binding-head screws which secure the wire clips to the cardan, and remove the wire clips. Remove the six binding-head screws which connect the wire leads to the slip-ring assembly (6), and remove the wire leads. If care is taken in removing the leads so that they retain the same shape as they did on the cardan, it may be easy to replace them in exactly the same position.

(c) Remove the two fillister-head screws attaching the terminal block (17) on the side opposite the contact plate assembly, and remove the terminal block.

(d) Remove the four long flathead screws (5) which pass all the way through the slip-ring assembly (6) and fasten it to the cardan (7). This will permit the slip-ring assembly to be lifted off as an assembly.

(e) Scribe marks on both the upper and lower gudgeon pins (4 and 11) and on the cardan (7) so that the gudgeon pins may be replaced on the cardan in the same position as before they were removed. Remove the six fillister-head screws (3) securing the upper gudgeon pin (4) to the cardan, and remove the upper gudgeon pin. The gudgeon pin may be tapped lightly with a soft hammer to loosen it from the cardan.

(f) Remove the three flathead screws (12) securing the lower gudgeon pin (11) to the cardan; insert two 6-32 screws through the puller holes, screwing them in evenly until the gudgeon pin is free from the cardan.

Note

Early model stabilizers have a precessing motor built into the base of the housing. The precessing motor serves no useful function in the operation of the C-1 autopilot system. Therefore, no maintenance of any kind is required on the precessing motor; however, if

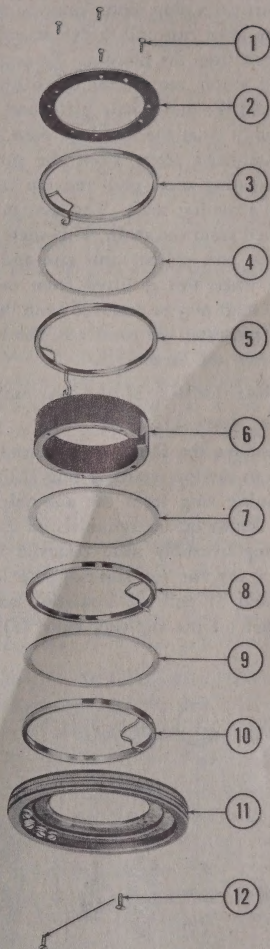


**Figure 252 — Slip Ring Assembly
Exploded View**

Index No.	Nomenclature
1.	Screws
2.	Slip Ring Clamp Washer
3.	Slip Ring and Lead Wire Assembly
4.	Slip Ring Spacer
5.	Slip Ring and Lead Wire Assembly
6.	Slip Ring Drum
7.	Insulating Ring
8.	Slip Ring and Lead Wire Assembly
9.	Slip Ring Spacer
10.	Slip Ring and Lead Wire Assembly
11.	Slip Ring Base
12.	Screws

the stabilizer is equipped with a precessing motor, this precessing motor must be removed before the rotor case and cardan assembly may be removed from the housing. To remove the precessing motor, remove the five fillister-head screws from the motor base plate, and remove the assembly from the housing. Also, remove the fillister-head screw from the precessing motor actuating shaft gear and the taper pin from the actuating shaft. The gear may then be removed as part of the rotor case and cardan assembly when this is lifted from the housing. The shaft may be removed from the lower gudgeon pin after the rotor case has been removed from the cardan.

(10) DISASSEMBLE SLIP-RING ASSEMBLY.

(See figure 252.)

(a) Remove the four short flathead screws (1) which remain in the top retaining ring (2), and remove the top retaining ring from the assembly. Since the binding-head screws on the terminals on the lower side of the slip-ring assembly were removed in removing the lead wires, the two top slip-ring and lead wire assemblies (3 and 5) and the insulating ring (4) may now be slipped off the slip-ring body (6).

(b) Remove the two flathead screws (12) which attach the slip-ring base (11) to the slip-ring body (6); remove the slip-ring base, pulling off the two lower slip-rings and wire assemblies (8 and 10) and insulating ring (9) from the slip-ring body.

(c) The two resistance coils may be removed from the slip-ring base by pulling the ends of the wire from the holes through which they pass to the base terminals.

(11) DISASSEMBLE THE ROTOR AND CASE ASSEMBLY.

(a) (See figure 253.) The locking screws (1) and gudgeon pins (2) have already been removed. Scribe a mark on the bearing sockets (4 and 10) and also on the case (7) so that the bearing sockets may be replaced in exactly the same position.

(b) Remove the four fillister-head screws (11) fastening locked bearing socket (10) to the rotor case, and remove the bearing socket and bearing (9) from the rotor case. Place the bearing, socket, and locking plug (8) immediately into a covered container, and mark properly for identification. Any shims found under the locked bearing, or under the locked bearing socket, should be placed in the covered container with the bearing and socket. It is usually not necessary to remove the locking plug (8) from the bearing (9).

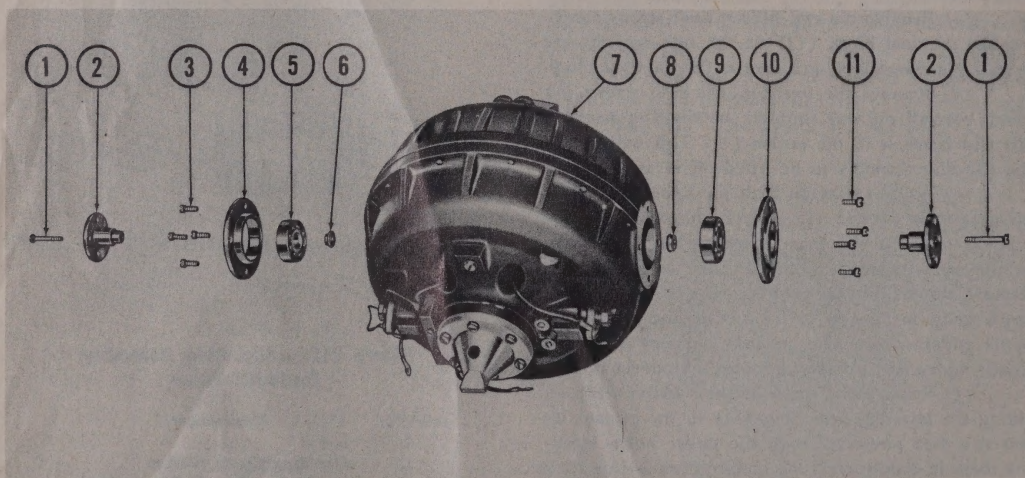


Figure 253—Rotor Case Bearings, Exploded View

Index No.	Nomenclature
1.	Locking Screws
2.	Gudgeon Pins
3.	Screws
4.	Free Bearing Socket
5.	Free Bearing
6.	Locking Plug

Index No.	Nomenclature
7.	Rotor and Case Assembly
8.	Locking Plug
9.	Locked Bearing
10.	Locked Bearing Socket
11.	Screws

when fastened in place. Check the fit of the lower cardan bearing on this gudgeon pin, making sure that the bearing fits snugly on the pin, but not so tightly that it cannot be pushed into place with the fingers.

(c) Inspect the upper cardan gudgeon pin (4) carefully to make sure that there are no burrs on the tapered portion and that the screw threads have not been damaged. Check the fit of this gudgeon pin into the counterbore at the top of the cardan, making sure that it fits snugly into position, but that metal is not picked up to prevent it from seating properly. If the tapered portion which fits into the clutch drum has been damaged, the gudgeon pin should be replaced. Also, test the fit of this gudgeon pin in the leather washer in the housing cover to make sure that the washer fits snugly around the gudgeon pin. If misfit at this point is found, however, the washer, not the pin, should be replaced.

(d) (See figure 252.) Inspect all parts of the cardan slip-ring assembly for any damage which might impair its operation. Examine the base (11), drum (6), and clamp washer (2) for any cracks, or other damage. Check carefully the tapped holes in the base and the drum to see that no threads have been stripped. Examine the fiber spacers (4, 7, 9) to see that they have not become frayed; if they have, replace them. Take particular care in examining each slip-ring (3, 5, 8, 10) to make sure that the lead wires have not become loosened. These lead wires should not show any signs of excessive bending, and the connection between the lead wire and the slip-ring should be checked with an ohmmeter to make sure that the connection is good. Examine the two resistance coils that fit into the grooves of the base assembly (11); if they appear to be damaged, or bent out of shape, they should be replaced. Check the resistance of each of these resistance coils with an ohmmeter. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. These resistance coils are designated as R7 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the coil. Coils which do not come up to this specification should be removed and replaced with new coils. Be sure that coils are firmly in place in the grooves on the base; if coils are loose, shellac them in place. Make sure that the ends of the wires are clean so that they will make proper contact under the binding-head screws at the terminals. Examine the slip-rings for corrosion; if they are not clean and bright, polish them with a very fine, abrasive polishing cloth.

(e) (See figure 250.) Examine the contact plate assembly (16) carefully. If the contact plate seems to have separated from the insulating material, or if the assembly seems to be warped so that the wiper will not

make proper contact, it should be replaced as an assembly. If the surfaces are rough or damaged, the contact plate assembly should also be replaced. Clean the contact surfaces thoroughly with carbon tetrachloride (U. S. Army Specification No. 4-503-110B), and wipe dry with cotton tape. If there are slight scratches on the surface of the contact plate, it may be polished off with a very fine, abrasive polishing cloth. Using an ohmmeter, check to see that there is no contact between the two contact plates on each side of the assembly. Make sure that the four tapped holes into which the terminal screws enter have not been damaged, or threads stripped. In case of damage, replace the entire assembly.

(f) Examine the cardan terminal block (17) to make sure that the tapped holes do not have stripped threads. Examine the wires leading from the slip-ring assembly and from this terminal block to make sure that insulation is in good condition. Examine the small clips that hold these wires to the edge of the cardan. If any of these parts are damaged, replace them.

(g) Check the cardan drive gear (2) carefully for damaged teeth which would impair operation; if damage is noticed, replace the gear. Make sure that the gear fits snugly in position on the cardan and that screw holes line up properly. This precaution is particularly important when this gear has been replaced.

(7) TORQUE MOTOR ASSEMBLY.

(a) Carefully check the fit of all bearings. Clean all bearings, as outlined in the preceding paragraph. Replace those bearings which appear to be defective.

(b) Clean all gear teeth with a brush and carbon tetrachloride (U. S. Army Specification No. 4-503-110B) and blow dry with filtered compressed air. Examine the teeth of all gears and pinions carefully for burrs, nicks, or wear. Very small nicks or scratches may be removed with a knife edge Arkansas stone, using a stroke parallel with the teeth. When the gear meshes with its mating pinion and does not run free and easily, the gear or the pinion should be replaced. Most wear will be observed on the pinion of the armature (6, figure 245), the bronze intermediate gear (4, figure 245), the bronze upper clutch gear (10, figure 243), and the bronze pinions on the clutch and pinion assemblies. If any noticeable wear is apparent on these bronze gears and pinions, check carefully their operation with the mating gear or pinion; if there is any doubt about proper operation, replace the bronze gear or pinion. In the case of the clutch and pinion assembly, the entire assembly must be replaced if the pinion is not satisfactory. The complete cardan drive pinion and gear assembly (11, figure 243) must be replaced if any part is found defective.

(c) (See figure 263.) Examine the clutch and pinion assemblies (1) to make sure that the surface of the clutch disc has not been scratched or nicked in the area which contacts the cork insert in the gear assembly (4). If this surface is damaged in any way, replace the clutch and pinion assembly. If the rounded surface of the steel button (5) on the under side of the assembly has been nicked or scratched, it may be polished off smooth with a fine polishing paper. However, if this operation is necessary, it will probably be necessary in reassembly to change the clutch magnet armature in order to obtain the proper air gap between the magnet and the armature and, therefore, obtain the proper torque. Check the clearance between the bore of the clutch and pinion assembly (1) and the clutch gear stud shaft (2). If this clearance is excessive, replace either the stud or pinion assembly, depending upon which part is worn. Wear usually occurs in the clutch and pinion assembly.

Note

Make sure that the four small air holes (3) in each clutch and pinion assembly are open. If these are clogged, open them with a fine wire. Make sure also that the air holes in the stud shafts (2, figure 244) are open to permit the passage of air; if clogged, clean out with a small wire.

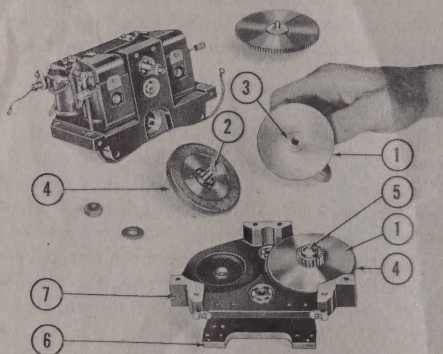


Figure 263 — Examining Clutch and Pinion Assemblies

Index No.	Nomenclature
1.	Clutch and Pinion Assemblies
2.	Gear Stud
3.	Air Holes
4.	Gear Assemblies
5.	Steel Button
6.	Mounting Bracket
7.	Plate Assembly

(d) Inspect both the bronze and steel clutch upper gear assemblies (4), paying particular attention to the condition of the cork insert. It is very important that these cork inserts be in good condition and absolutely flat, without high spots or glazed surface. The conditions of these corks will determine the friction on the clutch disc and, therefore, the torque applied by the torque motor. If the corks are only dirty, they may be cleaned with wood alcohol; but care must be taken to use only a small amount of alcohol, as an excess will loosen the shellac with which the corks are fastened to the gear assemblies. No attempt should be made to replace these cork inserts, or to polish down high spots, unless proper equipment is available for grinding them down absolutely flat and to the proper thickness. If corks are replaced, make sure that replacement corks are free from high spots unless these high spots occur only on one side, in which case the high spots may be placed next to the gear assembly. Put the cork in the recess of the gear with a thin film of orange shellac; press the cork in place, allowing it to dry under a pressure of 10 pounds for approximately 24 hours. Corks must then be ground smooth with a fine, revolving emery stone, with the gear mounted in a suitable fixture. Corks should be ground down to approximately 3/64 inch above the surface of the gear. After grinding, pick out any particles of shellac which may have come through the porous cork and appear on the smooth ground surface. If corks require replacement, and suitable equipment for grinding them down to the required flatness and thickness is not available, the entire gear assembly should be replaced. If the corks are resurfaced or replaced, the thrust buttons on the magnet armature will probably have to be replaced in reassembly in order to provide the proper torque application to the cardan.

(e) (See figure 244.) Examine each stud shaft (2) carefully to make sure that it fits snugly into the top plate and that the clearance is satisfactory between the stud shaft and clutch and pinion assembly (1 and 8). When the clearance is satisfactory, the clutch and pinion assembly will slide evenly from the stud shaft under its own weight, yet fit snugly around the shaft. Also, check the fit of the bearing (4) in the clutch gear assembly (3 and 7). Make sure that the bearing fits snugly on the shaft, but may be pressed into place with the fingers.

(f) (See figure 263.) Inspect the slip-ring contact block mounting bracket (6) which fastens to the top of the plate assembly, to make sure that threads have not been stripped from the tapped holes. If threads appear to be stripped, replace the mounting bracket.

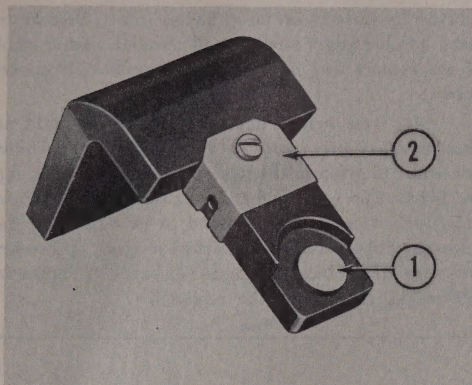


Figure 264 — Clutch Magnet Armature Assembly

Index No.	Nomenclature
1.	Thrust Plug
2.	Spacer

(g) (See figure 264.) Check the clutch magnet armature assembly for damage to the thrust plug (1) which presses against the clutch and pinion assembly, and for wear on the copper spacer (2) which is fastened to the armature with a fillister-head screw. If the plug is damaged, it should be replaced. The thickness of this plug will determine the torque applied by the motor; therefore, it must be checked later in making this adjustment during reassembly. If the spacer is worn, or badly bent, it should be replaced. The knob and pin assembly on which the clutch magnet armature turns should be carefully inspected for wear; if wear is apparent, or if the pin is bent out of shape, it should be replaced. Carefully check the fit of the pin in the magnet armature to make sure that it turns freely on the pin. Also check the fit of the pin in the clutch magnet armature frame to make sure that it may be easily inserted. If the clutch armature spring stops are bent out of shape, or are distorted, they should be replaced.

(h) (See figure 245.) Check the fit of the bronze intermediate gear (4) on the intermediate pinion shaft (1), making sure that the taper pin (5) which fastens it to the shaft is in good condition and fits tightly. Be sure that the shaft fits properly in the bearing (3).

(i) (See figure 247.) Examine each of the two clutch magnet coils (2) to make sure that the covering is not damaged. Examine all of the wiring to the coils for damaged insulation. If damage is detected, the wire should be replaced. If tapped holes in the flanges of the coils have been stripped, the coil must be replaced. Check the resistance of the coils with an ohmmeter.

Check the resistance of the clutch magnet damping resistors. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. Clutch magnet coils are designated as F5 and damping resistors as R8 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the necessary parts.

(j) (See figure 246.) Examine the torque motor field coils (5) for damage to the covering, or damaged insulation of the wires leading to the coils. If damage is detected, the damaged parts should be replaced. Make sure that the tapped holes in the flanges do not have stripped threads. If the threads are damaged, the entire coil must be replaced. Check each field coil with an ohmmeter. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. Torque motor field coils are designated as F4 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the coil.

(k) (See figure 245.) Examine the commutator and bracket assembly (10). Make sure that the ball bearing fits snugly into the counterbore provided, but not too tight to prevent its being pushed into place with the fingers. Examine both the grounded and insulated brush holders; if any damage is detected, or if brushes do not slide freely in the holders, the holders must be pushed out and replaced. Care must be used in pressing new holders into place to see that they are properly positioned and that only about 3/64 inch protrudes from the bracket on the inside next to the commutator. In pressing in the insulated brush holder, be very sure that the insulating tube does not crack.

(l) Inspect and repair the torque motor armature and commutator assembly in accordance with the procedure outlined in this section, paragraph 2, d, (15), (e).

(8) ROTOR CASE BEARING SOCKETS.

(See figure 253.)

(a) Check rotor case bearing sockets (4 and 10) to make sure that they are free from scratches, or nicks of any kind, which might prevent the locked bearing socket from seating firmly against the rotor case, or which might prevent the free motion of the free bearing in its socket. Polish out nicks or scratches with a fine polishing cloth. If this will destroy the fit of the socket, it must be replaced.

(b) If either socket is replaced, make sure that it fits properly in the rotor case (7) and also that the bearing used with it fits snugly, but may be pressed in place with the fingers. If the locked bearing socket is replaced, shims previously used may not be correct to lock the bearing properly in place. It will be necessary to use extreme care in making this adjustment in reassembly.

(9) ROTOR AND CASE ASSEMBLY.—The cleaning, inspection, testing and repair of the various components of the rotor and case assembly are exactly the same as for the rotor and case assembly used in the vertical flight gyro. Check carefully all material given on the rotor and case assembly in this section, paragraph 2, d, (15), and perform all of the inspections and repairs indicated.

(a) (See figure 254.) Carefully inspect the locked bearing clamps (8) and the locked bearing cap (5); if these parts are damaged, replace them.

(b) Clean the torque motor actuating wiper contact with a piece of chamois or cotton tape dampened with carbon tetrachloride (U. S. Army Specification No. 4-503-110B). The wiper should be free from kinks. Examine the contact point carefully. It should have a 1/32-inch bevel on top and bottom as shown in figure 265. It is the width of these bevels which determines the amount of gyro precession required to close the contact and produce torque motor action. Bevel edges should be parallel to each other and to the insulation between segments of the contact assembly when installed. The contact may be beveled or flattened by

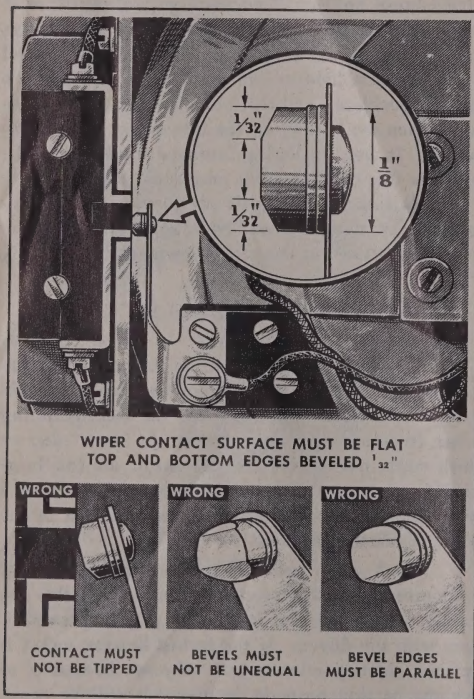


Figure 265 — Details of Torque Motor Actuating Wiper Contact

rubbing its surfaces on an Arkansas stone. Be sure to make beveled edges straight and parallel. Adjustment of the contact will be made in the reassembly procedure.

(c) Test field coil resistance carefully with an ohmmeter. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. The gyro field coils are designated as F3 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the coil. If brushes are worn to 3/4 inch in length (or less), as shown in figure 266, they should be replaced.

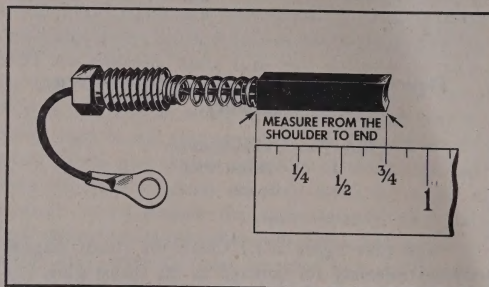


Figure 266 — Brush Length

(10) AUTOPILOT CLUTCH ASSEMBLY. (See figure 240.)

(a) Check all parts of the autopilot clutch assembly for wear or damage; replace any damaged parts. Keep all steel parts of this assembly covered with a fine film of light oil to prevent rust. Wear in the links and toggle mechanisms cannot always be detected by inspection; but when the operation of the assembly is checked, as part of the test procedure, section VII, any wear which will make the assembly operate incorrectly will be detected, and the parts can be replaced.

(b) Slip the autopilot clutch band (12) over the autopilot clutch drum (13); secure the clutch drum to the bombsight clutch drum (20) with the four fillister-head screws (14). Check carefully to see that the two drums fit properly and that there is clearance between the drum flanges and the clutch band. Slip the autopilot clutch adjusting spring (16) and the clutch adjusting screw collar (17) over the clutch adjusting screw (15) so that the spring rests up against the knob on the screw; then screw the adjusting screw into the clutch band.

(c) Place the clutch drum on the bench. Holding the bombsight clutch drum with one hand, clutch in and test the pull required to slip the clutch on the drum at the radius of 2 inches of the clutch connecting rod stud as shown in figure 267. This is done by at-

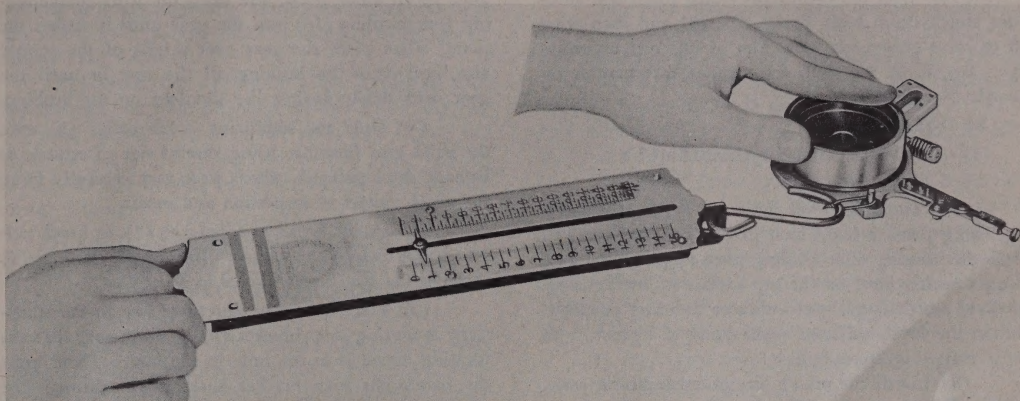


Figure 267 — Testing Autopilot Clutch

taching a spring scale to the stud and applying the force at right angles to the radius. Screw up on the adjusting knob until the pull required to slip the clutch is from 10 to 12 pounds. Test the clutch in four different positions to make sure that this same pull is required to slip the clutch at four different points equally spaced around the circumference. Any great variation in the pull required at various points around the circumference indicates that the clutch band is not properly fitted to the drum, and the parts should be replaced.

Note

If parts must be replaced, it is usually necessary to select or fit the clutch drum to the clutch band. This must be done to provide a clutch tension which will permit adjustment of the clutch to slip when a force of from 10 to 12 pounds is applied to the connecting rod stud. Experience has shown that if a force of 4 to 6 pounds is required to slip the band on the drum when no spring tension is required, no difficulty will be experienced in making the proper adjustment with the adjusting knob.

(11) BOMBSIGHT CLUTCH ASSEMBLY. (See figure 239.)

(a) Inspect the clutch band (13) to make sure that the connecting rod stud and the clutch lever stop pin are properly in place and have not been damaged. If either the pin or the stud has been damaged, it may be pulled or driven out and replaced with a new pin.

(b) Inspect all other parts in this assembly for damage. Wear on these parts will be checked when the assembled unit is tested for operation during reassembly.

(c) Test the bombsight clutch band and drum for fit in the same way as the autopilot clutch was tested

in step (10), preceding, except that the testing radius of the stud is $3\frac{1}{2}$ inches. This test should be made at this time to see that the parts fit properly so that when the clutch is assembled it may be adjusted to require a force of 18 to 24 pounds to slip the clutch at this radius. Experience has shown that if a force of approximately 8 pounds is required to slip the clutch band on the clutch drum when no spring tension is required, no difficulty will be experienced in making the proper adjustment to 18 to 24 pound slippage after the clutch is assembled. A careful checking of the fit at this point may save an additional disassembly of the clutch at the time when final adjustment is made.

(12) BOMBSIGHT CONNECTING ROD ASSEMBLY. (See figure 239.)

(a) Examine the rod (8) closely to make sure that it is not bent. This will also be checked carefully in the reassembly procedure.

(b) Make sure that the pin assembly (12) fits snugly in the rod and that no other parts are damaged. The rod must be carefully fitted to the bombsight clutch assembly, but this, also, must be done in the assembly operation.

(13) BOMBARDIER'S TURN KNOB. (See figure 259.)—Inspect all parts of the bombardier's turn control for damage. If the friction washer (9) is not in good condition, replace it with a new one. If the cup washer (5) has become bent in removal, it should be replaced. Be sure that the actuating lever fits snugly on the stem (12) but turns freely.

(14) RUST PREVENTION.—After the housing and housing top cover have been thoroughly cleaned with carbon tetrachloride (U. S. Army Specification No. 4-503-110B) they should be given a protective coat of Tectyl No. 502 rust preventative. This material may be

brushed on. Coat the bombsight clutch drum and autopilot clutch drum with Tectyl No. 502 and then wipe off to leave only a very fine film of this rust preventative. See T. O. 11-30-26 for further information on Tectyl No. 502.

e. REASSEMBLY.

(1) ASSEMBLE HOUSING ASSEMBLY.

(See figure 257.)

(a) Install the level indicator (4) on the housing, using three 3-48x1/4-inch fillister-head screws (5). Place the housing on a leveling plate (figure 226) and, using a master level on the top surface of the housing, check to see that the level indicator indicates properly. Adjust the level indicator with shims, if necessary, to get a correct level reading.

(b) Install the pilot's directional indicator scale, using a 3-48x9/16-inch fillister-head screw. Be careful to see that the scale is parallel to the top of the housing. If the electrical outlet receptacle hole cover has been removed, it should be replaced with four 6-32x5/16-inch fillister-head screws.

(c) Install the drift angle scale assembly (7) by slipping the assembly over the two dowel pins and fastening it in place, using two 4-40x5/16-inch fillister-head screws and two 4-40x3/8-inch flathead screws.

(d) Install pilot's directional indicator switch (15) and switch panel assembly (1).

1. Because of the soldered leads in the switch panel assembly, it should not have been disassembled unless some switch or AN receptacle was defective. If the switch or connector was replaced, the connection was resoldered in the repair of this assembly. Therefore, no reassembly of this assembly is necessary at this time. The pilot's directional indicator switch is soldered to a lead from the switch panel assembly and, therefore, can be considered part of it.

2. Insert the pilot's directional indicator switch (15) in the hole in the housing provided, slip the panel lock bracket over the switch, and secure the switch in place, using the switch lock nut furnished. Install the small single lead wire clamp (14) directly under the switch, using a 2-56x1/4-inch fillister-head screw, and place the lead wire to the switch under this clamp. Install the large lead wire clamp on the other side with a 4-40x5/16-inch fillister-head screw, and place the clamp over the covered lead wires which run to the brush torque motor and potentiometer.

3. Secure the switch panel assembly (1) to the stabilizer housing, using four 4-40x7/16-inch fillister-head screws (2).

(2) REASSEMBLE BOMBSIGHT MOUNTING STEM BRACKET ASSEMBLY.

(See figure 258.)

(a) Place the drift compensating gear (2) on a

plate in an arbor press, and press the drift compensating gear bushing (16) into the gear until it strikes the plate. Then place the gear over a hole of the proper size, and press the bushing all the way in until the gear seats firmly against the shoulder on the bushing.

(b) Slide the stabilizing brush collar (5) over the drift gear bushing, being careful not to scratch or damage these surfaces, which were very carefully fitted for good contact in inspection and repair.

(c) Install brush arm bracket (7) to brush collar, using two 6-32x5/8-inch fillister-head screws (4) through the two outside holes in the collar.

(d) Place the brush stop plate (8) on the bombsight mounting stem bracket (9), making sure that the locating dowel is in the hole in the plate. Then insert the bombsight stem bracket bushing (1) through the gear assembly, with the collar in place on the gear bushing, and, placing the bracket in an arbor press, use a smooth, easy pressure to press the bushing (1) into the bracket (9). Press the bronze bushing into the bracket until there is a clearance of from .0015 to .003 inch, as measured with a thickness gage between the shoulder of the bronze bushing and the top of the steel drift gear bushing as shown in figure 268.

(e) Turn the bracket over and drop any shims removed from the under side of the bracket in on top of the bottom edge of the bronze bushing. Install the bombsight stem socket (12), using four 4-40x3/8-inch fillister-head screws (11). Be sure to line up the scribe marks so that the socket will be installed in the same

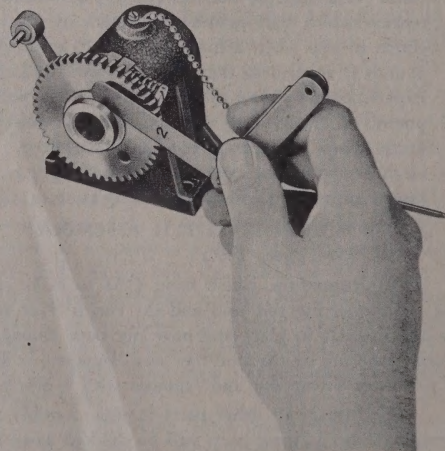


Figure 268 — Measuring Clearance Between Drift Gear and Bronze Bushing

position as it was originally. Attach the bombsight stem pin chain (10) to the bracket, using a 4-40x $\frac{1}{4}$ -inch fillister-head screw.

(f) Insert the drift gear collar adjusting stud (6) through the hole provided on the collar; slip the adjusting spring (14) over the stud, and install the adjusting nut (15). Adjustment at this point will be made after the bracket has been installed on the stabilizer housing.

(3) INSTALL BOMBSIGHT MOUNTING STEM BRACKET ASSEMBLY AND POTENTIOMETER BRUSH ARM ASSEMBLY.

(a) (See figure 257.) Install the pointer, with contact, to the brush arm, using one 2-56x $\frac{1}{4}$ -inch fillister-head screw and one 2-56x $\frac{3}{8}$ -inch fillister-head screw. The longer screw is installed farthest from the point of the pointer. Slip the lug from the longest lead wire coming from the switch panel assembly over the projecting end of the longer of these two screws, and, with a flat washer and nut, secure it in place. Be sure that the right connection is made by checking continuity against the "No. 8" prong of the AN receptacle on the switch panel. Loop the lead wire as shown in figure 269, and fasten it in the lead wire clamp which is, in turn, fastened to the brush arm with a 2-56x $\frac{1}{4}$ -inch binding-head screw and washer.

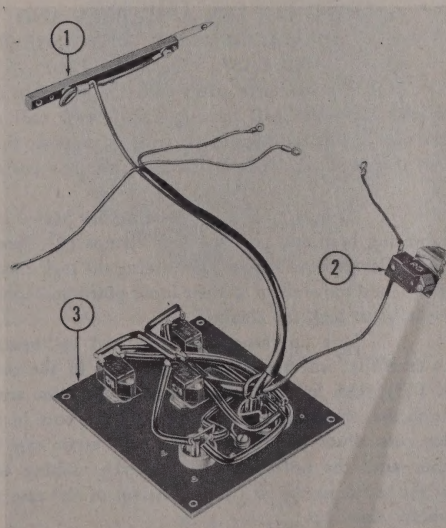


Figure 269 — Switch Panel Wiring

1. Brush Arm Assembly
2. Pilot's Directional Indicator Switch
3. Switch Panel Assembly

(b) (See figure 258.) Insert the end of the brush arm assembly (13) through the hole in the housing and into the recess in the brush arm bracket (7), fastened to the brush collar on the bombsight stem bracket assembly. Fasten the brush arm in place, using a 6-32x1-inch fillister-head screw (3), inserted through the hole in the drift compensating gear (2).

(c) (See figure 257.) Slide the bombsight mounting stem bracket assembly (8) over the dowels on the housing; fasten it to the housing, using four 8-32x $\frac{3}{4}$ -inch fillister-head screws (9). Check the clearance between the brush arm pointer and the scale. If clearance is more than .008 inch, place a shim between the scale and housing to give proper clearance.

(4) INSTALL THE POTENTIOMETER ASSEMBLY.

(a) (See figure 261.) Fasten the potentiometer body assembly (2) to the mounting plate (4), using two 4-40x9/16-inch fillister-head screws. Be sure to place at least one potentiometer spacer (3) between the body assembly and plate. Fasten the ground bracket to the plate, using a 2-56x3/16-inch binding-head screw and flat washer. Fasten the ground bracket to the potentiometer body assembly, using a 2-56x5/16-inch binding-head screw and flat washer.

(b) (See figure 241.) Pull the black lead wire from the pilot's directional indicator switch out through the opening; attach it to the end terminal of the potentiometer assembly, using a 2-56x5/16-inch binding-head screw and flat washer. Select the lead wire attached to the "No. 9" prong of the AN receptacle (by using an ohmmeter), and connect this lead wire to the center tap on the potentiometer body with a 2-56x3/16-inch binding-head screw and two lock washers and nut. Then insert the potentiometer assembly (2) into the hole in the housing, and insert the four 4-40x $\frac{3}{8}$ -inch fillister-head screws (1) which attach it to the housing. Do not tighten these screws, however, until after the rotor and cardan assemblies are installed.

(5) INSTALL LOWER CARDAN BALL BEARING SOCKET. (See figure 257.)

(a) Remove the lower cardan ball bearing (11) from its covered container; insert it in the lower cardan ball bearing socket (12), making sure that it fits in snugly, but may be pressed in with the fingers.

(b) Lining up the scribe marks, install the lower cardan ball-bearing socket in the bottom of the housing assembly, using six 6-32x9/19-inch flathead screws (13).

(6) ASSEMBLE ROTOR AND CASE ASSEMBLY.

(a) INSTALL BRUSH HOLDERS AND TERMINAL BLOCK. (See figure 254.)—Slip the brush holder insulator tubes over the brush holders, and press

the two brush holders into the commutator end half of the case (13). Push the brush holders in until the inside end of the holder is lined up with the outer edge of the bearing bushing in the case. Be sure that the terminal lug on the brush holder is away from the case and that care is taken to match scribed marks. Install the gyro rotor case terminal block, using two 2-56x7/16-inch fillister-head screws.

(b) ASSEMBLE AND INSTALL ROTOR
FIELD ASSEMBLY AND BEARING
CLAMPS. (See figure 254.)

1. Slip the pole pieces (17) through the windings (10); secure the pole pieces to the field ring, using two 8-32x1/2-inch flathead screws (11). Make sure that the lead wires from the field coils extend out the end of the field ring (12) which is tapped for the screws (16) which fasten the ring to the case.

CAUTION

The pole pieces of the field assembly must be properly lined up so that they will not touch the armature, and the air gap between the armature and pole pieces will be approximately the same at all points. If no fixture for lining up these pole pieces is available, a sufficiently accurate alignment may be obtained by fastening the ring (12) into the rotor case (13), and using a discarded armature with commutator end bearing attached to aid in obtaining alignment. First perform step 3, following. Then wrap paper around the discarded armature until it will just fit snugly between the pole pieces and insert the commutator end bearing into place in the bore of the case. This will bring the pole pieces into proper alignment with the armature axis, and the paper wrapped around the armature will assure clearance between the armature itself and the pole pieces at all points. Then tighten securely the flathead screws holding the pole pieces in place.

2. Using a staking tool, stake the ring at the end of the screw driver slot in the flathead screws (11) so that the screws will be locked in place.

3. Install the rotor field assembly into the commutator end rotor case (13), using two 6-32x13/16-inch fillister-head screws (16). If the parts previously used are being reassembled, line up the scribe marks on the side of the field ring and in the inside of the rotor case. The leads from the field coils will extend directly out through the holes provided, with the two short leads extending out on the side to which the actuating contact wiper is fastened.

4. Insert the armature shaft ball-bearing lock clamps (8) into the recesses provided in the rotor plain

end case assembly (7), and secure in place with two 6-32x1/2-inch fillister-head screws (3) with flat washers. Push the clamps into their outer position, and tighten the screws just enough to hold the clamps in this position.

(c) ASSEMBLE ROTOR ASSEMBLY.
(See figure 256.)

Note

If no dynamic balancing machine is available, this assembly should not have been disassembled, as it must be dynamically balanced after assembly into housing. If either ball bearing was removed from the rotor shaft, or if the armature was removed from the rotor, dynamic balancing is absolutely necessary.

1. Fasten the armature and shaft assembly (5) to the rotor (4), using eight 8-32x3/8-inch fillister-head screws (3).

2. Remove the two rotor ball bearings (2 and 6) from the covered containers in which they were placed after inspection and oiling; put them onto the rotor shaft, taking care to get them on the end to which they were fitted. Screw the bearing retaining nuts (1 and 7) up tightly, taking care to get the nut without the shoulder on the commutator end.

Note

Wipe off rotor carefully and cover it with a thin film of light oil to prevent rust.

(d) ASSEMBLE THE ARMATURE AND
ROTOR ASSEMBLY INTO THE RO-
TOR CASE. (See figure 254.)

1. Slip the rotor plain end case assembly (7) over the plain end ball bearing, taking care that the outer race of this self-aligning bearing is properly lined up so that it slides easily, but snugly, into the bearing bore.

2. After the plain end bearing has passed into the bearing bore and past the lock clamps (8), loosen the two fillister-head screws (3) holding the lock clamps in place, and move them to their inner position. Tighten the screws to lock the clamps.

3. Line up the commutator end ball-bearing race carefully; insert the commutator end of the rotor case (13), with field assembly attached, over the armature so that the ball bearing slides into the bore in the rotor case. Push the two halves of the rotor case together until the holes line up properly, making sure that the scribe marks on the two halves of the case are properly lined up.

CAUTION

Do not force bearings into the bearing bores of the cases. When properly lined up, they will slide in easily.

4. Insert the twelve 6-32x9/16-inch fillister-head screws (1) which hold the two halves of the rotor case together. Before these screws are tightened, make sure that the scribe marks on the case line up properly. It is a good idea to slip the rotor case bearing sockets in place in the counterbore before tightening these fillister-head screws, to make sure that the counterbores line up. Tighten all 12 fillister-head screws securely to hold the two halves of the rotor case together.

Note

If dynamic balancing equipment is available, or if the rotor was disassembled, dynamically balance the rotor in the case before installing end caps.

(e) **INSTALL BRUSHES AND CONNECT LEAD WIRES.** (See figure 270.)—Fit brushes, as outlined in this section, paragraph 2, d, (15). Test the brush tension with a spring scale. This tension, at the point when contact is broken, must be adjusted from 3½ to 4 ounces. Twist the two longer field coil leads (1 and 2) together; install the one (1) farthest from the terminal block (3) to the terminal on that end of the block with a 3-48x3/16-inch binding-head screw and flat washer. Connect the other lead (2) and the

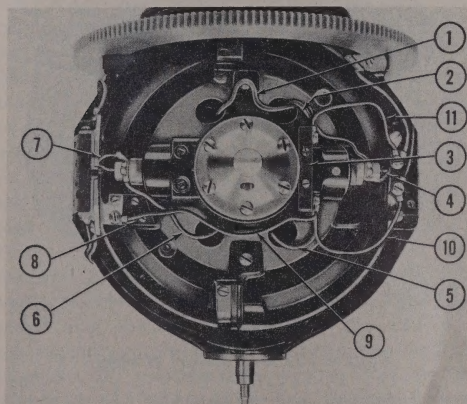


Figure 270 — Rotor Case Wiring

Index No.	Nomenclature
1.	Field Coil Lead
2.	Field Coil Lead
3.	Terminal Block
4.	Brush Lead
5.	Field Coil Lead
6.	Field Coil Lead
7.	Brush Lead
8.	Wiper Contact Block
9.	Lead Wire
10.	Flex Lead
11.	Flex Lead

brush lead (4) to the brush holder on the side nearest the terminal block (3), using a 3-48x1/4-inch binding-head screw. Connect the shorter (5) of the two short field coil leads to the terminal block (3), using a 3-48x1/4-inch fillister-head screw and flat washer. Connect the remaining field lead (6) and the brush lead (7) to the brush holder terminal on the opposite side from the terminal block, using a 3-48x3/16-inch binding-head screw. Shape the brush lead wires so that they extend straight out from the tension adjusting plug for at least 3/16 inch, and so that they do not touch any portion of the case.

(f) WARM UP AND CHECK ROTOR SPEED.

—Place the rotor and case assembly on the rotor case stand; connect a 26-volt dc power source to the upper terminal screw on the terminal block and to the rotor case. Allow the unit to warm up for approximately one hour. Check the operating speed, using a stroboscopic tachometer. This speed should be approximately 7500 to 8000 rpm. Check the current to the unit with an ammeter. This should be approximately 1.0 ampere. If the rotor speed is incorrect, or if the current required is too high, the unit should be disassembled to determine the cause.

(g) INSTALL ROTOR END CAPS.

(See figure 254.)

1. Drop several thousandths thickness of shims (6) on top of the outer race of the plain end bearing, and insert the plain end rotor case cap (5). Install at least two screws in this cap; pull the screws up tightly so that the outer race of the bearing is pushed up against the bearing clamps. When these screws are pulled up tight, there should be a space between the end cap and the rotor housing. If there is no space here, add several thousandths of additional shims between the end cap in the bearing, and repeat the above steps.

2. Check the space between the flange of the end cap and the rotor housing with a thickness gage as shown in figure 271. Then, removing the end cap, remove from beneath the end cap shims totalling in thickness .0005 inch less than the space measured between the end cap and the rotor case with the thickness gage.

3. (See figure 254.) Replace the end cap with hole down, or so that hole is on same side of rotor case as locating surface for actuating contact wiper. Install the six 6-32x7/16-inch fillister-head screws (2) which fasten the end cap to the housing. If measurements of shims and with the thickness gage were properly made, there will now be .0005-inch clearance between the end cap and the housing. With this much clearance, the locked bearing will be properly locked against the clamp when the fillister-head screws attaching the cap are pulled up tight. Insert the two 7/8-inch special locking

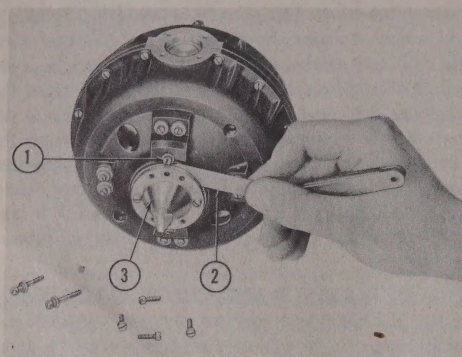


Figure 271 — Measuring for Fit of Locked Rotor Bearing End Cap

Index No.	Nomenclature
1.	Locking Screw
2.	Thickness Gage
3.	End Cap

screws (4) through the end cap and into the locking clamps.

4. Slip the end cap (15) on the commutator end of the rotor in place, making sure that the hole in the end cap is on the bottom side, which is the side to which the torque motor actuating contact wiper is fastened. Fasten this end cap in place, using six 6-32x 7/16-inch fillister-head screws (14).

(7) ASSEMBLE CARDAN ASSEMBLY.

(See figure 250.)

(a) Install cardan terminal block (17) on side of cardan, using two 3-48x $\frac{3}{8}$ -inch fillister-head screws.

(b) Install torque motor actuating contact plate assembly (16) on the opposite side of the cardan, using two 3-48x9/16-inch fillister-head screws.

(c) ASSEMBLE AND INSTALL CARDAN SLIP-RING ASSEMBLY.

1. (See figure 252.) Place the slip-ring (10), the insulator (9), and the slip-ring (8) on the slip-ring drum (6), bringing the slip-ring leads out of the bottom slot of the slip-ring drum.

2. Fasten the slip-ring and resistance base (11) to the slip-ring drum (6), using two 4-40x $\frac{3}{8}$ -inch flathead screws (12). Make sure that the side of the drum having the eight holes is away from the base and that the slot in the drum closest to the base is on the side of the base having the tapped holes for the two terminal screws.

3. Slip the two remaining slip-ring and lead wire assemblies (3 and 5) over the drum, making sure

that there is a fiber slip-ring spacer (4 and 7) separating each slip-ring from the adjacent ring. Be sure that the lead wires from the two bottom slip-rings (8 and 10) pass through the bottom notch in the drum (6) which is closest to the base, and that the lead wires from the two top slip-rings (3 and 5) pass through the top notch in the drum. If these slip-rings have not been replaced, make sure that the slip-rings with the two short wires go on *first*, with the lead wires passing through the lower notch, and that the two slip-rings with the long wires go on *last*, with the lead wires passing through the upper notch.

4. (See figure 272.) Hold up the base and drum assembly with the two tapped terminal screw holes in the base at the top, as shown in figure 272. Starting with the left-hand hole at the top, number the terminal screw holes clockwise, 1, 2, 3, 4, 5, and 6.

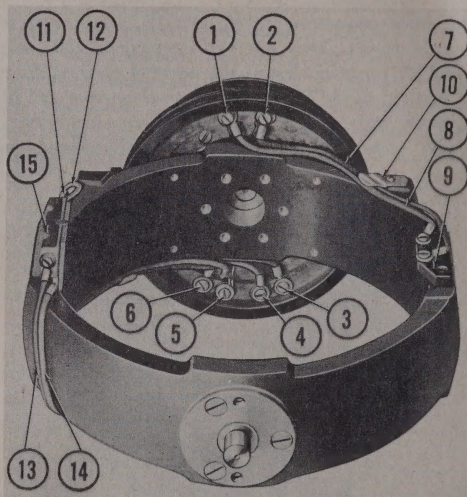


Figure 272 — Cardan Wiring

Index No.	Nomenclature
1.	Terminal No. 1
2.	Terminal No. 2
3.	Terminal No. 3
4.	Terminal No. 4
5.	Terminal No. 5
6.	Terminal No. 6
7.	Black Lead Wire
8.	Red Lead Wire
9.	Terminal Block
10.	Lead Wire Clamp
11.	Black Lead Wire
12.	Red Lead Wire
13.	Black Lead Wire
14.	Red Lead Wire
15.	Contact Plate Assembly

This makes the two top holes reading left to right, Nos. 1 and 2, and the bottom holes, reading right to left, Nos. 3, 4, 5, and 6. Adjust the lead wires on the two lower slip-rings so that the lead wire from the bottom slip-ring can be attached to terminal No. 2, and the lead wire from the next-to-the-bottom slip-ring can be attached to terminal No. 1, without the lead wires crossing. Arrange the two top slip-rings so that the lead wire from the next-to-the-top slip-ring can be attached to terminal No. 5, and the top slip-ring to terminal No. 4, without the lead wires crossing.

5. (See figure 252.) Install the bakelite slip-ring clamp washer (2) on top of the drum, using four 4-40x $\frac{3}{8}$ -inch flathead screws (1). This will lock the slip-rings in place on the drum.

6. Coat the grooves in the slip-ring and resistance base (11) with shellac. Wrap the resistance coils around the base so that they fall in the grooves provided, taking care not to bend the resistance coils out of shape and making sure to insert the ends of the coils through the small holes in the base provided for this purpose. The two ends of the bottom resistance coil attach to terminal Nos. 3 and 4 (figure 272,) which are immediately adjacent to the holes through which the ends of these coil wires project to the inside. Using a 4-40x $\frac{1}{4}$ -inch binding-head screw and flat washer, attach the one end of the bottom resistance coil and one lug of a black lead wire $7\frac{1}{4}$ inches long to terminal No. 3. The resistance wire end should be placed in between the washer and the lug so that it will not twist off in tightening down the terminal screw. Using a 4-40x $\frac{5}{16}$ -inch binding-head screw and two flat washers, attach the lug of a red lead wire $6\frac{3}{8}$ inches long and the other end of the bottom resistance coil and the lead wire from the top slip-ring to terminal No. 4. Place the flat washers between the wires to assure good contact. In the same manner, fasten one end of the upper resistance coil, the lug of a red lead wire 9 inches long, and the lead wire from the next to the top slip-ring, to terminal No. 5. The remaining wire from the top resistance coil, together with one lead of a black lead wire 9 inches long, is fastened with a 4-40x $\frac{1}{4}$ -inch binding-head screw to terminal No. 6. Using a 4-40x $\frac{1}{4}$ -inch binding-head screw and one flat washer, fasten the lead from the next to the bottom slip-ring and one lug of the red wire $5\frac{1}{2}$ inches long to terminal No. 1. Using a 4-40x $\frac{1}{4}$ -inch binding-head screw and flat washer, fasten the lead wire from the lower slip-ring and one lug of a black wire $5\frac{1}{2}$ inches long to terminal No. 2.

7. (See figure 250.) Secure the slip-ring assembly (6) to the cardan with four 4-40x $1\frac{1}{2}$ -inch flat-head screws (5), making certain that the side of the base with two terminal screws is on the same side of the

cardan as are the contact plate assembly (16) and the terminal block (17).

8. (See figure 272.) Form the black and red lead wires (7 and 8) from the terminal Nos. 1 and 2 carefully around the edge of the cardan, connecting the red lead wire (8) to the top terminal of the cardan terminal block (9), using a 3-48x $\frac{1}{4}$ -inch binding-head screw with a flat washer, and the black lead wire (7) to the bottom terminal of the cardan terminal block, using a 3-48x $\frac{1}{4}$ -inch screw with flat washer. Lock these wires in place on the edge of the cardan, using a two-wire cardan lead wire clamp (10) and a 2-56x $\frac{1}{4}$ -inch fillister-head screw. Form the black and red lead wires from terminal Nos. 3 and 4 around the edge of the cardan toward the contact plate assembly, so that they will cross over directly under the cardan gear to attach to the two top terminals of the contact plate assembly (15). Fasten the red lead wire (12) from terminal No. 4 to the top terminal of the contact plate assembly, using a 2-56x $\frac{1}{8}$ -inch binding-head screw. Fasten the black lead wire (11) from terminal No. 3 to the remaining terminal on top of the contact plate assembly with a 2-56x $\frac{1}{4}$ -inch binding-head screw. Form the black and red lead wires from terminal Nos. 5 and 6 around the same side of the cardan. Secure all wires from terminal Nos. 3, 4, 5, and 6 with a four-wire clamp fastened to the cardan with a 2-56x $\frac{1}{4}$ -inch fillister-head screw. Then, continue the wires from terminal Nos. 5 and 6 on around the cardan. Secure them to the cardan below the gudgeon pin with a two-wire hold-down clamp block and a 2-56x $\frac{1}{4}$ -inch fillister-head screw. Bring these two lead wires across the cardan; fasten the red lead wire (14) to the bottom terminal of the contact plate assembly using a 2-56x $\frac{1}{8}$ -inch binding-head screw, and the black lead wire (13) to the remaining contact on the bottom of the contact plate assembly, using a 2-56x $\frac{1}{4}$ -inch binding-head screw.

CAUTION

In all cases where lead wires are held in place by clamps, wrap the lead wires together, using about 3 turns of scotch tape in the places where the clamps fit over the wires.

(d) (See figure 250.) Install the lower gudgeon pin (11) to the cardan, using three 8-32x $\frac{1}{2}$ -inch flat-head screws (12), taking care to line up the scribe marks made when the gudgeon pin was removed.

(e) Install the cardan upper gudgeon pin (4), using six 8-32x $\frac{1}{2}$ -inch fillister-head screws (3), taking care again to line up the scribe marks made in disassembly.

(8) INSTALL ROTOR AND CASE ASSEMBLY IN CARDAN ASSEMBLY.

(a) INSTALL ROTOR CASE BEARINGS.

1. (See figure 253.) Place rotor and case on

stand. Remove the locked bearing (9) from its covered container. Cover the locked bearing socket (10) with a fine film of oil. Insert the bearing into the socket, making certain that the locking plug (8) is in place in the taper of the inner race, and that this plug is toward the inside.

2. Insert the locked-bearing socket into the counterbore of the rotor case (7) on the side where the torque motor actuating contact wiper is installed, taking care to line up the scribe marks on the bearing socket and on the case. Secure the socket in place, using four 4-40x5/16-inch fillister-head screws (3). Check to make sure that the locked bearing still slides freely in the locked-bearing socket by screwing one of the locking screws into the locking plug and moving the bearing in the socket. Then, remove the four screws used in securing the socket to the case. Push the bearing socket all the way into the counterbore; with a thickness gage, check the space between the bearing socket and the case (figure 273). This should be only .0005-inch clearance to assure proper locking of the bearing without distortion of the outer bearing race. To obtain the correct clearance at this point, first insert several shims into the counterbore of the rotor case so that the locked bearing rests against these shims when the bearing and socket are put into place. Then, measure the space between the bearing socket and the case with a thickness gage. Remove shims totalling this amount, less .0005 inch. Clearance between the socket and the case will then be .0005 inch, and the socket



Figure 273 — Measuring for Fit of Locked Rotor Case Bearing Socket

may be secured in place with the use of four 4-40x5/16-inch fillister-head screws (3).

3. (See figure 253.) Remove the free bearing (5) from its covered container, and insert it into the bearing socket (4). Cover the socket with a fine film of oil. Make sure that the free bearing slides easily in and out of the free bearing socket. Making sure that the locking plug (6) is in place, and toward the inside, slip the free bearing socket into the counterbore in the rotor case, taking care to line up the scribe marks and secure the socket in place with four 4-40x5/16-inch fillister-head screws (3). Check to make sure that the free bearing still slides freely in the free bearing socket, by screwing one of the locking screws into the locking plug and moving the bearing in the socket.

(b) INSTALL ROTOR CASE ASSEMBLY IN
CARDAN. (See figure 250.)

1. Slip the cardan assembly over the rotor and case assembly, being careful not to scratch the inside of the cardan with the fillister-head screws which hold the rotor case bearing sockets to the case. Also, be sure that the tapped holes to which the torque motor actuating contact wiper is attached are on the same side as the contact assembly. Insert the locked bearing gudgeon pin (15) on the side having the locked bearing, being careful to line up the scribe marks made when this bearing gudgeon pin was removed. Then, insert the free bearing gudgeon pin (10) on the opposite side, also lining up the scribe marks. Secure the two gudgeon pins to the cardan, using four screws with 4-40x 3/8-inch oval-head in each gudgeon pin.

2. Before inserting the locking screws (8 and 13) into the bearings, check the end play of the rotor case between the gudgeon pins. To do this, use a taper gage (figure 274) inserted between the rotor case and the inside of the cardan. Make sure that the rotor case slides easily from one limit of end play to the other. The minimum end play at this point should be .006 inch. If this end play is less than .006 inch, shims should be inserted under the free bearing gudgeon pin to give the correct end play.

3. Insert the two locking screws through the gudgeon pins; pull the screws up tight, locking the inner races of the two rotor case bearings tightly to the gudgeon pins.

(c) INSTALL TORQUE MOTOR ACTUATING WIPER AND FLEX LEADS. (See figure 270.)—Install torque motor actuating contact wiper block (8) on the rotor case, using two 2-56x3/16-inch fillister-head screws with flat washers. Then, install the contact wiper on the contact wiper block, using one 2-56x3/16-inch fillister-head screw and also a 2-56x3/16-inch binding-head screw, with a flat washer

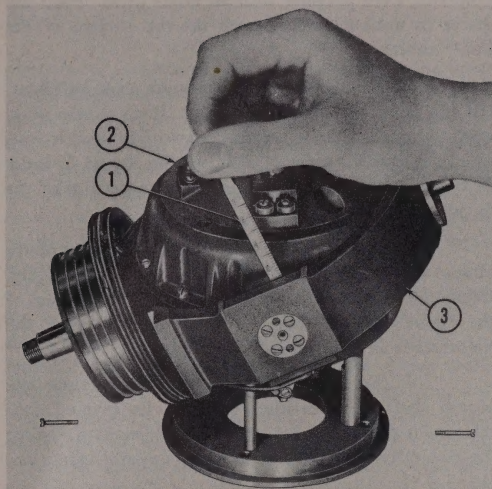


Figure 274 — Checking End Play of Rotor Case in Cardan

Index No.	Nomenclature
1.	Taper Gage
2.	Rotor Case Assembly
3.	Cardan Assembly

slipped through one terminal lug of a 41/8-inch lead wire (9). The binding-head terminal screw is installed in the hole farthest away from the wiper contact. Place the other lug of this black lead wire together with one lug of a 37/8-inch flex lead (10) under the lower terminal screw of the rotor case terminal block (3). One field coil lead is already attached to this terminal. Connect the other end of this flex lead to the lower terminal on the cardan terminal block. Attach the other 37/8-inch flex lead (11) between the top terminal screw on the cardan terminal block (that is, the one to which the red lead wire runs) and the top terminal screw on the rotor case terminal block. A field coil lead is already attached to this top terminal screw on the rotor case terminal block.

(d) **ATTACH CARDAN GEAR.** (See figure 250.) Attach the cardan drive gear (2) to the cardan, using six 8-32x1/2-inch fillister-head screws (1). Make sure that the scribe marks on the cardan and on the cardan drive gear line up so that the gear is replaced in the same position from which it was removed.

(9) ASSEMBLE TOP HOUSING COVER ASSEMBLY. (See figure 249.)

(a) Slip the cardan upper ball-bearing dust protector washer (7) into place in the counterbore in the

top of the housing cover (9). Fasten the dust protector washer retainer (6) in place, using three 3-48x1/4-inch fillister-head screws (4).

(b) Check to see that the autopilot clutch stop screws (5) are in place on the cover assembly; if these were removed, screw these stop screws into place. Make sure that the ventilation cover stop pin is in place. Fasten the ventilation cover (11) onto the housing cover, using the shoulder screw (12). Make sure that the ventilation cover may be easily swung from one side to the other.

(c) Remove the cardan upper gudgeon ball bearing (10) from its covered container; insert it into the counterbore in the top housing cover. This bearing should fit easily so that it may be pressed into place with the fingers.

(10) INSTALL CARDAN AND ROTOR CASE ASSEMBLY INTO HOUSING.

(a) (See figure 248.) Grasp the cardan and rotor case assembly (3) by the cardan drive gear, and lower it carefully into the housing assembly (2) until the gear is level with the top of the housing. Then, resting the gear on the top of the housing, shift the hands under the gear through the holes in the two opposite sides of the housing, and carefully lower the assembly until the lower cardan gudgeon pin enters the inner race of the cardan ball bearing. Great care must be taken to see that the assembly does not injure the lower gudgeon bearing, the potentiometer, or any wiring in the installation. Be sure that the rotor is not tilted to a maximum position in the cardan when installing the assembly.

(b) Tighten the four screws which hold the potentiometer assembly to the housing.

(c) (See figure 249.) Place the top housing cover assembly over the upper cardan gudgeon pin, and position it on the housing. Fasten the top housing assembly to the housing, using a 6-32x3/8-inch flathead screw (3) in the one hole having a beveled counterbore, and a 6-32x9/16-inch fillister-head screw (2) through the course centering pointer (8), and six 6-32x1/2-inch, fillister-head screws (1) in the remaining holes in the housing cover assembly. There should be at least .006 inch of end play of the cardan in its bearings when the top cover is secured in place. To determine the end play, use a 1- to 2-inch depth gage to measure the distance from the top of the upper gudgeon to the top surface of the dust collar, when the assembly is upright and the cardan and rotor case assembly has shifted its weight toward the bottom. Now shift the cardan and rotor case assembly toward the top of the housing by using the leverage of the fingers between the cardan drive gear and the top cover and place the assembly on its side. Again measure the distance from the top of

the gudgeon to the top surface of the dust collar. The difference between the two readings is the end play. If the end play is less than .006 inch, a shim will have to be placed between the lower cardan ball bearing socket and the housing. If a bombardier's turn knob is to be installed on the stabilizer, the two fillister-head screws which would ordinarily be installed in the two holes to which the bombardier's turn control is attached may be omitted. These screws will be inserted when the turn control is put in place.

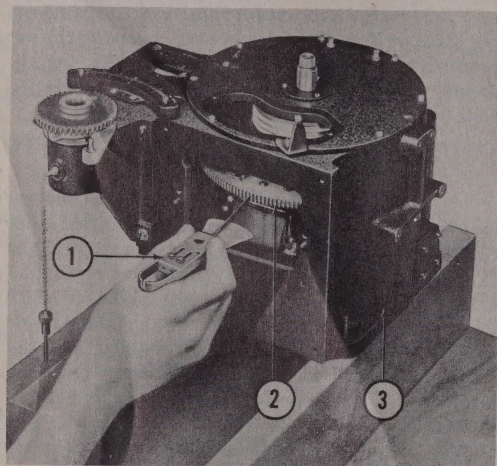


Figure 275—Checking Freedom of Rotation of Cardan in Cardan Bearings

Index No.	Nomenclature
1.	Gram Gage
2.	Cardan Drive Gear
3.	Housing

(d) (See figure 275.) With a gram gage, apply a force to a tooth of the cardan gear to test the freedom of rotation of the cardan to its bearings. A force of 5 grams (or less) should be sufficient to turn the cardan assembly in the housing. Make this test at a number of points throughout the circumference of the cardan drive gear; if more than a 5-gram force is required to move the assembly, remove it from the housing to determine the cause.

(11) ASSEMBLE TORQUE MOTOR AND CLUTCH ASSEMBLY.

(a) ASSEMBLE TORQUE MOTOR.

1. (See figure 245.) Insert the armature shaft bearing spacer (11) in the counterbore provided for the armature shaft bearing (3) in the torque motor frame assembly. Press the spacer in from the top, applying

a smooth, even pressure with an arbor press. Press the spacer in until it is flush with the top surface of the frame assembly.

2. Remove the upper armature shaft ball bearing (3) from its covered container. Press it into place from the under side of the frame assembly until it rests snugly against the spacer. This bearing should fit snugly, but not too tightly to be pressed into place with the fingers.

3. (See figure 243.) Remove the cardan drive pinion shaft bearing (12) from its covered container. Using the fingers, press it into place from the top of the frame assembly until it seats firmly against the counterbore in the frame.

4. (See figure 245.) Remove the intermediate pinion shaft ball bearing (2) from its covered container. Using the fingers, press it into position against the counterbore in the motor frame assembly from the top.

Note

Use extreme care in handling all bearings to keep dust or dirt from entering these bearings, which have been carefully cleaned and inspected.

5. (See figure 247.) Secure the two magnet armature frames (4) to the torque motor frame (5), using four 6-32x7/16-inch fillister-head screws (6). Make sure that the clutch magnet armature frame having one scribe mark is installed on the side of the torque motor frame which is also scribed with only one mark, and that the armature frame having two scribe marks is installed on the opposite side where the two scribe marks appear on the frame assembly (5).

6. Using two 8-32x5/8-inch fillister-head screws (7), attach the two clutch magnet coils (2) to the magnet armature frame securely, taking care that the terminal connections on each coil are on the outside as shown, so that there is no possibility of these terminals touching the frame. If the same coils are replaced as were formerly used in the assembly, it is best to make sure that each coil is replaced on the side from which it was removed, as this will make the adjustment for proper torque much easier when that point in reassembly is reached.

7. (See figure 246.) Install the two torque motor field coil assemblies (5) and the upper field frame (4) and lower field frame (6) by inserting the two special 6-32x2-3/16-inch fillister-head screws (1) through the upper field frame, then through the coils and through the lower field frame into the torque motor frame assembly (7). Pull these screws up tight to secure the field coils in place, making sure that the ter-

minals of the field coils are on top at the outside, as shown.

8. (See figure 245.) Assemble the armature commutator end bracket assembly by pressing the brush holder assemblies into place, if they were pressed out in disassembly. Be sure that the ears on these brush holders are away from the base of the bracket, and that the brush holders are pushed in only far enough so that they will be flush with the inside of the bracket. Remove the lower armature ball bearing (7) from its covered container, and push it into place in the armature commutator end bracket assembly (10).

9. Insert the torque motor armature assembly (6) between the two field frames so that the shoulder on the top end of the shaft (where the pinion is cut on the shaft) enters the upper armature bearing. Then, slip the armature commutator end bracket assembly (10) into place on the commutator end so that the armature shaft enters the lower bearing. Secure the bracket assembly in place on the torque motor frame assembly, using two 6-32x $\frac{5}{8}$ -inch fillister-head screws (8).

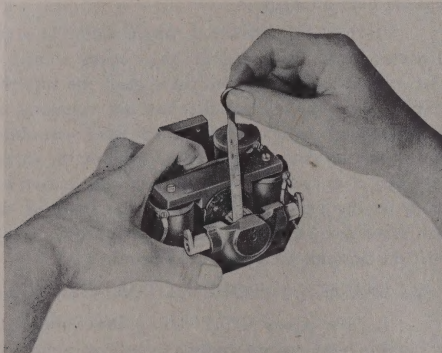


Figure 276 — Checking End Play of Armature

10. Check the end play of the armature in its bearing, using a taper gage (figure 276). If the end play is more than about .006 inch, it may be reduced by pressing the armature shaft bearing spacer (11, figure 245) farther into the frame assembly. If this end play is less than about .003 inch, the armature should be removed and the spacer pressed in the opposite direction to provide the proper end play.

11. Install intermediate pinion shaft (1) through the pinion shaft ball bearing, and slip the intermediate gear (4) on the under side of the pinion shaft after it passes through the ball bearing. Take care to line up the two tapered holes for the taper pin (5) which secures the intermediate gear to the pinion

shaft; press this taper pin in place, using a square-nosed pliers. Do not drive the pin in place, as this may spring the shaft or damage the ball bearing unless the hub of the gear is supported in some way.

WARNING

This pin must be seated tightly in place. If it should come loose in flight, lives will be endangered.

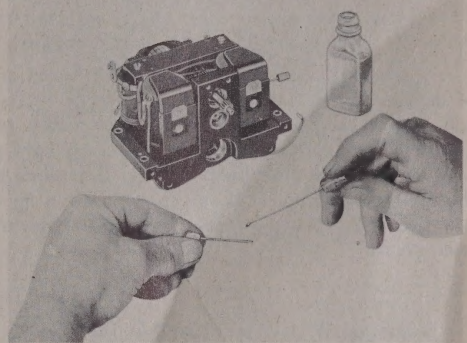


Figure 277 — Oiling Hinge Pins

12. (See figure 247.) Put the clutch magnet armature assemblies (1) in place, and insert the hinge pins (3) with the knob attached through the clutch magnet frames (4) and armature assemblies. Place one drop of light oil on the hinge pin as it is inserted (figure 277). If these magnet armatures and the thrust plugs attached to them were not replaced, it is important to get the armature with the single scribe mark on the side of the frame having the single scribe mark, and the one with the double scribe mark on the opposite side where the double scribe mark appears. This procedure will make the adjustment for the proper torque much easier when this operation is performed.

13. (See figure 246.) Install the two clutch magnet armature spring stops (3), using two 3-48x3/16-inch fillister-head screws (2) in each spring stop.

(b) ASSEMBLE TORQUE MOTOR CLUTCH GEAR PLATE ASSEMBLY.

1. (See figure 243.) Attach the cardan slipping contact block mounting bracket (2) to the torque motor plate (7), using 4-40x $\frac{3}{8}$ -inch flathead screws (1). The terminal plate is fastened to this bracket by means of one 3-48x $\frac{1}{4}$ -inch fillister-head screw.

2. Remove the torque motor intermediate pinion shaft ball bearing (9) from its covered container, and insert it in the counterbore provided in the torque motor plate. This bearing should fit snugly, but should be pressed in with the fingers.

3. Remove the cardan drive pinion shaft ball bearing (8) from its covered container, and press it into place in the torque motor plate with the fingers.

4. (See figure 244.) Remove the torque motor upper clutch gear ball bearings (4) from their covered containers; insert the bearing fitted to the steel gear (7) into the steel gear, and the bearing fitted to the bronze gear (3) into the bronze gear. Slip the upper clutch gear ball-bearing retainers (5) over each bearing. Secure each retainer to the gear, using three 2-56x1/4-inch fillister-head screws (6). Insert the stud shafts (2) through the clutch upper gear assemblies.

5. (See figure 243.) Insert the threaded end of the stud shafts through the plate assembly (7); secure them to the plate assembly with a flat washer (6) and the hex nut (5). Pull the hex nut up tight to lock the stud shaft in place. The correct position of the steel and bronze gear assemblies is shown in figure 278. Remember that the bronze gear meshes with the steel pinion.

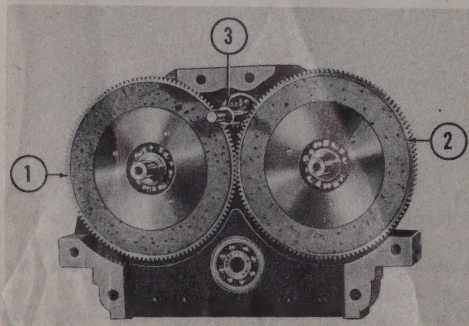


Figure 278 — Position of Steel and Bronze Gear Assemblies

Index No.	Nomenclature
1.	Steel Gear Assembly
2.	Bronze Gear Assembly
3.	Pinion

6. Place a drop of light oil (Army Air Force Specification No. 3582-A) on each stud shaft. Slide the clutch and pinion assembly which is marked with the single scribe mark on the inside of the hub over the stud shaft extending through the bronze gear assembly. Slip the other clutch and pinion assembly over the stud shaft extending through the steel gear assembly.

7. Insert the shaft on the cardan drive pinion and gear assembly (11) into the upper cardan drive bearing in the plate assembly so that the cardan drive gear meshes with the pinions of the clutch and pinion assemblies.

(c) ASSEMBLE CLUTCH GEAR PLATE ASSEMBLY TO TORQUE MOTOR.

(See figure 243.)

1. Slip the large lug on the short terminal wire over one of the torque motor dowel screws (3), and insert this dowel screw on the side of the steel gear (14). Insert the other torque motor dowel screw in the opposite hole, and tap both screws into place with a soft hammer.

2. Place the torque motor clutch gear plate assembly (7) on top of the torque motor frame assembly (13). Be careful that the dowel screws fit properly in place, that the torque motor cardan drive pinion and gear assembly shaft (11) enter the lower cardan drive gear bearing, and that the intermediate pinion shaft enters the upper intermediate pinion shaft bearing in the plate assembly.

3. Fasten the plate assembly securely to the frame assembly, using two 6-32x1-1/16-inch fillister-head screws (4) and two 6-32x1-7/16-inch fillister-head screws (15). Tighten these screws down securely, install two hex nuts on the two dowel screws (3), and pull these nuts up tight.

4. Hold the assembled torque motor in a vertical position and, using a gram gage, apply a force to one of the teeth of the cardan drive gear. Be sure that the clutch and pinion assemblies are not engaging the cork surfaces of either of the clutch gear assemblies. If more than 10 grams are required to turn the cardan drive gear, it is usually an indication that either one or both of the bearings into which the shaft of this cardan drive gear and pinion assembly fit are not seated against the bottoms of their counterbores.

(d) INSTALL TORQUE MOTOR WIRING.

1. (See figure 279.) Using two 2-56x5/16-inch binding-head screws and flat washers, attach the black lead wire (1), which connects the top terminals of the two torque motor field coils. Then, loosen the fillister-head screws which hold the field coils to the frame, and rotate the coils to take out any slack in this lead. Then, retighten the fillister-head screws, making sure that the terminal lugs do not touch the frame at any point.

2. Using two 2-56x5/16-inch binding-head screws, attach the black lead wire (2) between the lower terminals of the two clutch magnet coils to the magnets, making sure that one terminal lug of a clutch magnet damping resistor (4, figure 279 and 2, figure 280) is also connected at this point under each of these binding-head screws. Then, loosen the two fillister-head screws which secure the magnet coils to the frame, and rotate the coils to take out the slack in the terminal wire connecting the two coils together. Then, retighten these

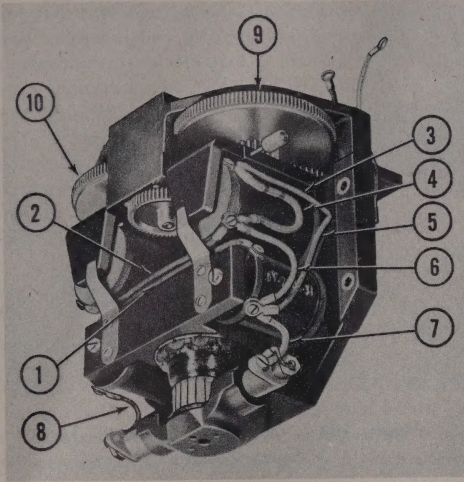


Figure 279 — Torque Motor Wiring, Bronze Gear Side

Index No.	Nomenclature
1.	Black Lead Wire
2.	Black Lead Wire
3.	Red Lead Wire
4.	Resistor
5.	Red Lead Wire
6.	Red Lead
7.	Red Lead
8.	Black Lead
9.	Bronze Gear Assembly
10.	Steel Gear Assembly

screws, after making certain that the terminal lugs do not touch the frame at any point.

3. (See figure 280.) Using a 2-56x5/16-inch binding-head screw, attach the 9/4-inch black terminal lead (1) and the other end of the clutch magnet damping resistor (2) to the remaining terminal on the clutch magnet under the steel gear assembly (3), and run this black lead wire through the hole in the frame provided.

4. (See figure 279.) Using a 2-56x5/16-inch binding-head screw, attach the 63/4-inch red lead wire (3) and the loose end of the clutch magnet damping resistor (4) to the remaining terminal on the magnet coil under the bronze gear (9), and run the red lead wire through the hole in the frame provided.

5. Using a 2-56x5/16-inch binding-head screw, attach the 95/8-inch long red lead (5), the 21/4-inch red lead (6), and the 15/8-inch red lead (7) to the remaining terminal on the torque motor field coil which is under the bronze gear assembly (9). Then, attach the

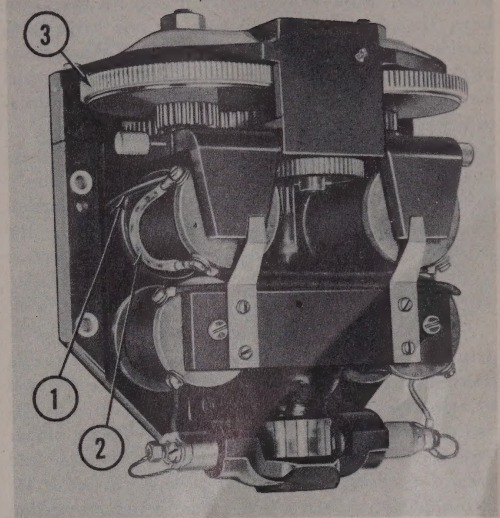


Figure 280 — Torque Motor Wiring, Steel Gear Side

Index No.	Nomenclature
1.	Lead Wire
2.	Damping Resistor
3.	Steel Gear Assembly

other end of the 21/4-inch red terminal lead to the lower terminal of the clutch magnet coil on that side. Insert the long red lead through the hole in the frame provided on that side, through which the long red lead from the clutch magnet coil has already been placed.

6. Using a 2-56x5/16-inch binding-head screw and flat washer, attach the 13/4-inch black lead (8) to the remaining terminal of the torque motor field coil which is under the steel gear (10).

7. (See figure 281.) Install the two wire clamps (2) onto the frame assembly and the two wire clamps (3) onto the plate assembly, using four 2-56x 1/4-inch fillister-head screws. Install the wires under these clamps, making sure that the long black lead (4) runs across and falls under the clamps on the opposite side with the short red lead (6) from that side, and that the long red lead (5) runs across and installs under the clamps on the opposite side.

(e) FINAL TORQUE MOTOR TESTS AND ADJUSTMENTS.

1. Install the torque motor brush scribed with the two scribe marks in the brush holder also scribed with two scribe marks. Be sure that the scribe marks

on the brush are toward the scribe marks on the holder so that the brush will properly fit around the armature. Then install the brush with the one scribe mark on the opposite side in the holder with the one scribe mark, again making certain that the two scribe marks are on the same side so that the brush will fit the armature properly.

2. If new brushes are being installed, these brushes must be fitted to the armature by placing a strip of fine polishing cloth around the motor commutator, and allowing the brush to 'ride' against it as the armature is turned back and forth until the curvature of the brush exactly fits the curvature of the commutator.

3. Turn the brush pressure adjusting plugs in part way. Then test the brush tension, using a spring scale. (See figure 282.) This tension must be adjusted by means of the adjusting plug to give from 3 to 3½ ounces of brush tension on each brush. After the proper tension is obtained, connect the lug on the brush lead wire to the brush holder terminal, using a 3-48x3/16-inch binding-head screw and a flat washer. In testing brush tension, it is best to connect an ohmmeter between the two brush holders so that the correct tension may be obtained at the exact moment when the

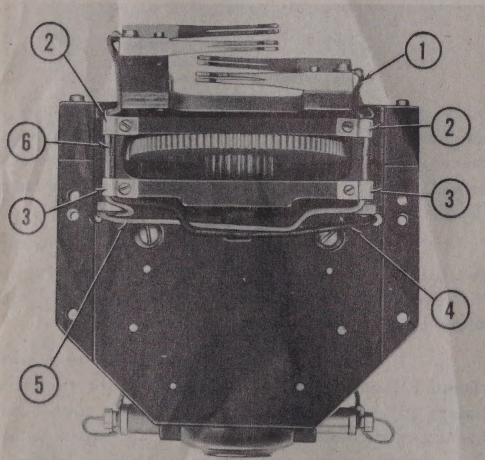


Figure 281 — Torque Motor Wiring, Housing Side

Index No.	Nomenclature
1.	Ground Lead
2.	Wire Clamps
3.	Wire Clamps
4.	Black Lead Wire
5.	Red Lead
6.	Red Lead Wire

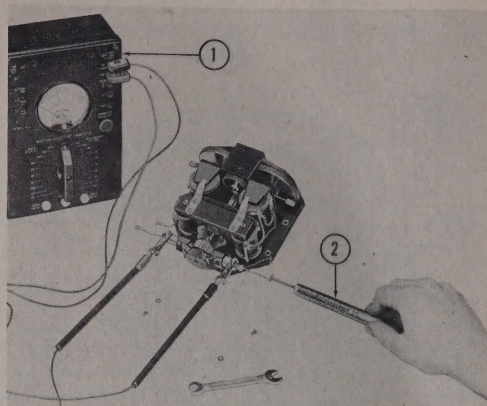


Figure 282 — Checking Torque Motor Brush Tension

Index No.	Nomenclature
1.	Ohmmeter
2.	Ounce Scale

brush leaves the commutator. The two short lead wires from the motor field coil should also be connected to the brush holder terminal at this time.

4. (See figure 283.) Using a thickness gage, check the clearance between each clutch and pinion assembly (2) and the cork insert of the gear assembly (3) with which it is mated. This must be done with the torque motor in a vertical position. This clearance

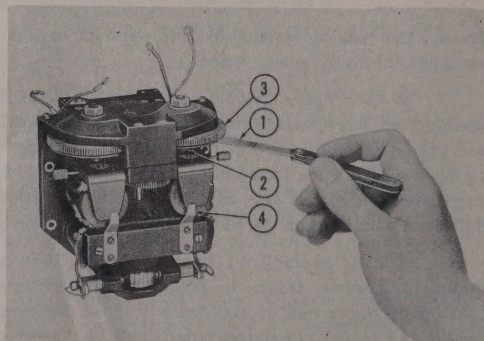


Figure 283 — Checking Clearance Between Clutch Disc and Gear Cork

Index No.	Nomenclature
1.	Thickness Gage
2.	Clutch and Pinion Assembly
3.	Gear Assembly
4.	Armature Spring Stop

should be from .015 to .020 inch. If the clearance is incorrect, the clutch magnet armature spring stop (4) must be bent slightly with the tweezers, either in or out, so that the correct clearance is obtained at this point. After adjustment, the portion of the spring stop which rests against the armature must be exactly parallel with the armature so that it makes contact over the entire surface of this portion of the spring stop. After this adjustment is made with the torque motor in a vertical position, the cardan drive gear should run free with no noticeable drag when turned with the fingers.

5. Connect a 26-volt d-c power supply to the ground terminal wire fastened under one of the dowel screws and the red motor lead on that side. With the torque motor in a vertical position, allow the motor to run for about one to two hours. If new gears have been installed, a 4-hour run-in period should always be used. During this run-in period, check the rpm of the motor, using a strobotac revolution counter and a colored spot painted on the shellacked surface at the lower end of the armature as a reference mark. This speed should read from 3980 to 4420 revolutions per minute, and current consumption at this speed should be not more than six-tenths of one ampere.

6. (See figure 284.) Place a film of heavy oil (Specification No. VV-0-581) over the thrust plugs on the magnet armatures. Bolt the assembled torque motor (1) to a torque motor test fixture (2), and connect the motor leads and magnet lead to a 26-volt d-c power source. With the motor running at rated speed, energize one of the magnets. Check the torque exerted on the cardan gudgeon pin on an arm (3) having a radius of 8 inches. Force at this radius on the gudgeon pin should be from 14 to 15¾ pounds. Energize each magnet separately, checking the torque exerted. Torque in each direction should be approximately the same (112 to 126 pound-inches). If the force exerted is less than 14 pounds, the magnet armature thrust plug may be too thick, providing too much of an air gap between the magnet armature and the magnet. If too much force is exerted, the magnet armature thrust plug (1, figure 264) may be too thin, and the air gap between the armature and the magnet too small. The thickness of the thrust plug may be varied by carefully filing down the plug to make it thinner, or if additional thickness is required, by removing the plug and replacing it with a thicker plug. However, before filing the thrust plug, it is advisable to loosen the two fillister-head screws holding the magnet armature frame to the motor frame and also the fillister-head screws securing the magnet to this frame, and slide the magnet armature frame up or down as much as possible to gain the equivalent of a thicker or thinner thrust plug. Then, tighten these three fillister-head screws. The adjustment possible in this manner is very slight, but often

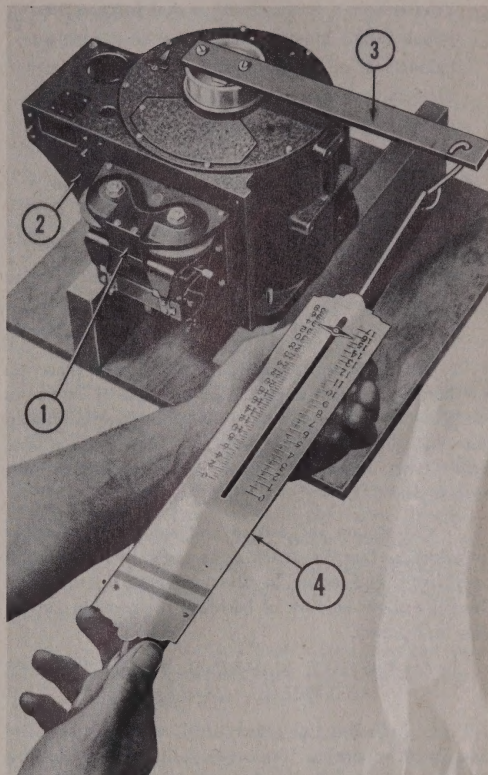


Figure 284 — Checking Pull of Torque Motor

Index No.	Nomenclature
1.	Torque Motor
2.	Test Fixture
3.	Testing Arm (8 inch)
4.	Spring Scale (Pounds)

it may be enough to make filing of the thrust plug, or insertion of a new thrust plug, unnecessary. When the necessary adjustments have been made, and the force exerted on the upper cardan gudgeon pin at 8-inch radius is between 14 to 15¾ pounds, the torque motor assembly may be removed and assembled into the stabilizer.

Note

The torque motor test fixture used consists of a stabilizer housing with the cardan and the cardan gear installed just as in a complete stabilizer, except that the rotor and case are not used. A bombsight clutch drum is bolted securely to the tapered upper cardan gudgeon

pin, and the torque motor test arm (*figure 236*) is bolted to the drum so that force at an 8-inch radius may be measured with a spring balance. If no fixture of this type is available, the stabilizer being overhauled may be used by assembling the cardan and gear assembly into the housing without the rotor assembly in place, installing the bombsight clutch drum, and bolting the test arm to it to provide an arm with an 8-inch radius to which a spring balance may be coupled for the test.

(12) INSTALL TORQUE MOTOR ON
STABILIZER HOUSING. (*See figure 241.*)

(a) Slide the torque motor (6) into place on the housing carefully, making sure that it slides in straight over the locating dowels, and that the cardan gear engages the pinion properly. Fasten the torque motor to the housing, using four 8-32x $\frac{3}{4}$ -inch fillister-head screws (7).

(b) Rotate the cardan and rotor case assembly to make sure that the cardan gear and its driving pinion turn freely and easily in all positions. Be sure that there is a slight amount of backlash between the cardan gear and pinion.

(c) INSTALL SLIP-RING BRUSH HOLDER
ASSEMBLIES. (*See figure 242.*)

1. Fasten the lower brush to the lower slip-ring brush mounting block (4), using a 3-48x $\frac{1}{4}$ -inch fillister-head screw in the hole closest to the tip of the brush. Install the upper brush (3) to the lower brush block, using a 3-48x $\frac{1}{4}$ -inch fillister-head screw in the hole closest to the tip of the brush.

2. Fasten the ground lead (1) from the torque motor to the lower brush on the lower brush holder assembly, using a 3-48x $\frac{1}{4}$ -inch binding-head screw and flat washer.

3. Connect the red lead from the switch panel to the upper brush (3) of the lower brush holder assembly, using a 3-48x $\frac{1}{4}$ -inch binding-head screw and washer.

4. Fasten the lower brush holder assembly (4) to the slip-ring contact block mounting bracket, using two 3-48x $\frac{7}{16}$ -inch fillister-head screws.

5. Fasten the lower brush to the upper brush mounting block, using a 3-48x $\frac{1}{4}$ -inch fillister-head screw in the hole closest to the tip of the brush. Fasten the upper brush to the upper brush mounting block, using a 3-48x $\frac{3}{4}$ -inch fillister-head screw in the hole closest to the tip of the brush.

6. Connect the red lead from the torque motor to the lower brush on the upper brush holder assembly (5), using a 3-48x $\frac{1}{4}$ -inch binding-head screw and flat washer.

7. Connect the black lead from the torque motor assembly to the upper brush on the upper brush holder assembly, using a 3-48x $\frac{1}{4}$ -inch binding-head screw and flat washer.

8. Connect the upper brush holder assembly (5) to the cardan slip-ring contact block mounting bracket, using two 3-48x $\frac{1}{2}$ -inch fillister-head screws.

CAUTION

Make sure that lugs on lead wires attached to brush holder assemblies do not touch any brush other than the one to which the lead wire is connected.

9. Connect the red lead from the left side of the torque motor and the blue lead from the cold side of servo switch on switch panel to the torque motor terminal plate (6) with a 3-48x5/16-inch binding-head screw and flat washer.

10. Check the tension of the brushes against their respective slip-rings. The tension should be between 110 and 150 grams. Check also to make sure that each brush slides in between the slip-ring spacers and thus eliminate the possibility of spacer wear.

(13) CHECK CONTINUITY OF ALL WIRING.

—Use an ohmmeter, as shown in *figure 285*, to make the following continuity checks. If continuity is not as indicated, improper wiring or connections are the cause. See wiring diagram, *figure 286*.

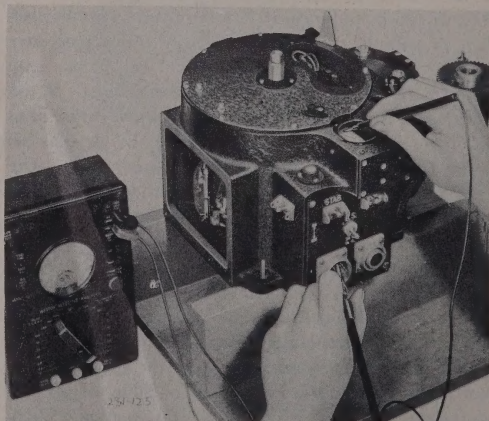


Figure 285 — Checking Continuity of Wiring

DIRECTIONAL STABILIZER
INTERNAL WIRING DIAGRAM

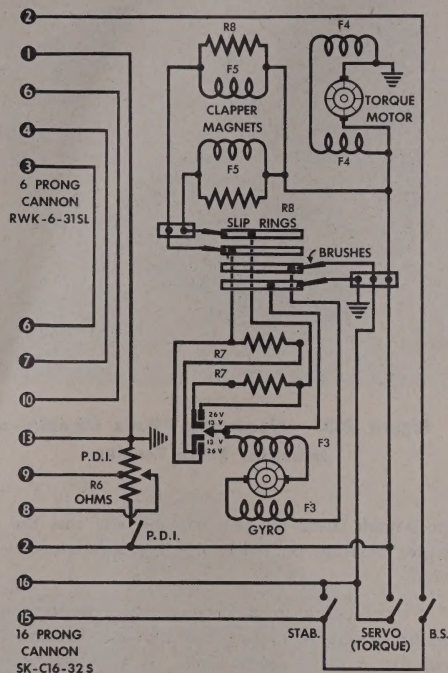


Figure 286 — Wiring Diagram

(a) Check for a closed circuit between prong "2" of the male AN receptacle and the inside terminal plate of the potentiometer, with the pilot's directional indicator switch closed. Open the switch to see that circuit is broken.

(b) Check for a closed circuit between prong "6" of the AN receptacle and terminal "3" of the female receptacle on the switch panel.

(c) Check for a closed circuit between prong "7" of the AN receptacle and terminal "4" of the female receptacle on the switch panel.

(d) Check for a closed circuit between prong "10" of the AN receptacle and terminal "6" of the female receptacle on the switch panel.

(e) Check for a closed circuit between prong "8" of the AN receptacle and the brush arm terminal.

(f) Check for a closed circuit between prong "9" of the AN receptacle and the center tap on the potentiometer.

(g) Check for a closed circuit between prong "13" of the AN receptacle and terminal "1" of the female receptacle on the switch panel. Prong "13" should also give a closed circuit to ground.

(h) Check for a closed circuit between prong "15" of the AN receptacle and the "No. 2" brush on the slip-ring assembly (numbering brushes "1", "2", "3", "4", from the bottom), with the stabilizer switch closed. Then, open the switch to see that the circuit is broken. Also, check for a closed circuit between prong "15" of the AN receptacle and the terminal "No. 2" of the female receptacle on the switch panel, with the bombsight switch closed. Then, open the bombsight switch to see that the circuit is broken.

(i) Check for a closed circuit between prong "15" of the AN receptacle and the terminal plate on the cardan actuating contact block mounting bracket, with the stabilizer closed and the servo switch closed. Open servo switch and make sure that the circuit is broken. A circuit is also established between prong "15" of the AN receptacle and the inside terminal of the potentiometer when the stabilizer switch, the servo switch, and pilot's directional indicator switch are all closed. Opening any of these three switches will break the circuit.

(j) Check for a closed circuit between prong "16" of the AN receptacle and the brush on "No. 2" slip-ring of the slip-ring assembly.

(k) Check for a closed circuit between the "No. 4" slip-ring brush and the top terminal on the torque motor magnet farthest from the bombsight mounting bracket. "No. 3" slip-ring brush should check off to the top terminal of the other torque motor magnet. "No. 1" slip-ring brush should form a closed circuit with ground.

(l) When the torque motor actuating contact wiper is in contact with the upper terminal of the contact assembly, the "No. 1" grounded slip-ring brush should give a closed circuit to the "No. 4" slip-ring brush. When the actuating contact wiper is in contact with the lower contact of the contact assembly, a closed circuit is formed between the "No. 1" slip-ring brush and the "No. 3" slip-ring brush. A circuit showing 190 ohms between "No. 1" and "No. 4" will result if the two long red leads (3 and 5) of the torque motor (figure 31), are disconnected from their terminals in the torque motor, and the torque motor actuating contact wiper is in contact with the first upper terminal of the cardan terminal block. A circuit showing 190 ohms between "No. 1" and "No. 3" will result, provided the same torque motor leads are disconnected and the contact wiper is in contact with the first lower terminal of the cardan contact block.

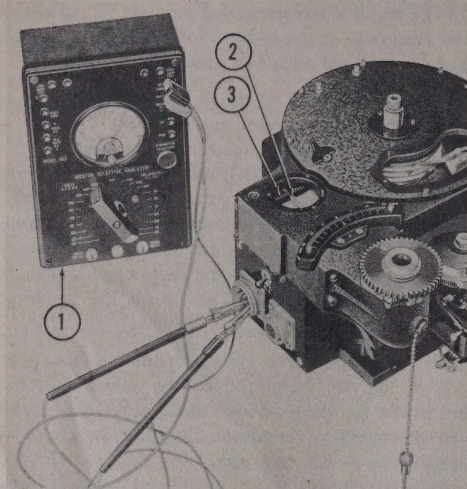


Figure 287 — Centering Pilot's Directional Indicator Potentiometer

Index No. Nomenclature

- | | |
|----|----------|
| 1. | Ohmmeter |
| 2. | Pointer |
| 3. | Scale |

(14) CENTER THE POTENTIOMETER.

(a) (See figure 287.) Line up the pointer (2) on the potentiometer brush assembly exactly with "0" on the wiper scale (3). Using an ohmmeter (1), check the resistance between the "8" and "9" prongs on the AN receptacle. If the potentiometer is properly centered, this should read 0 ohms. Then line up the wiper pointer, with the one-degree mark on the left side, and again check resistance. Record this resistance reading, and line the pointer up with the one-degree mark on the opposite side. Check this resistance against the resistance when the pointer was on the opposite side; if potentiometer is properly centered, the two resistance readings should be the same within five percent.

(b) (See figure 261.) If the zero reading does not read 0 ohms resistance, or if the reading at one degree on either side of 0 is not very nearly the same, it will be necessary to change the position of the potentiometer body assembly by inserting a spacing washer (3) of different thickness between the body assembly (2) and the plate (4) to which it is mounted. Spacers of varying thickness are provided, and the potentiometer body must be moved toward the side showing the greater resistance. After changing the spacer, make sure that

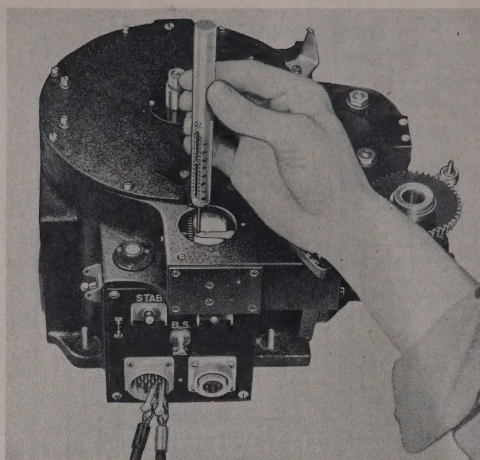


Figure 288 — Measuring Pilot's Directional Indicator Brush Tension

the 0-mark check is again 0 ohms, and that the one-degree readings on either side are approximately the same.

(c) Using an ounce scale, check the tension on the brush contact, making sure that it is between three and five ounces (figure 288). If this tension is incorrect, remove the potentiometer assembly and bend the pointer slightly to increase the tension. Make certain that the contact remains parallel to the windings of the potentiometer.

(15) CHECK THE FRICTION DRAG ON THE ROTOR CASE IN THE CARDAN AND THE CARDAN IN THE CARDAN BEARINGS.

(a) Using a gram gage reading from 0 to 10, applied against the outer tip of the rotor bearing cap, check the force required to force the cap down and also to force it up (figure 289). This should be checked on both ends of the rotor assembly, and the force required should not be more than two grams. However, if the force required to move it either up or down is considerably greater than to move it in the opposite direction, this may be caused by unbalance of the rotor and case assembly in the cardan, and an average of the two may be taken. In this case, it is well to proceed to balance the rotor and case; then again check the force after balancing.

(b) Check the force required to move the rotor case and cardan assembly and cardan drive gears

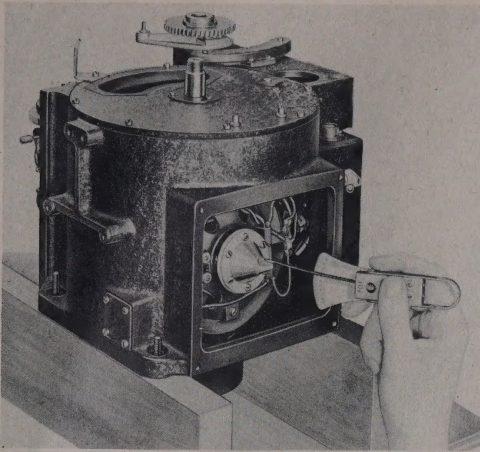


Figure 289 — Checking Freedom of Case Rotation

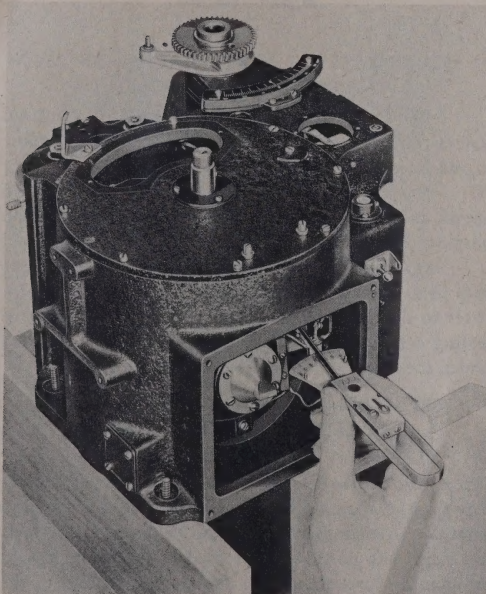


Figure 290 — Checking Friction Drag on Cardan

(figure 290). Using a gram gage registering up to 150 grams, apply force on the outer edge of the cardan gear with the gage. The force required to move the assembly should not be greater than 150 grams. A

check should be made in both horizontal directions and at least four different points on the gear 90 degrees apart.

(c) If the force required to move the cardan, or the rotor, in either of the above checks is too great, it indicates friction at some point, and a thorough check of the assembly should be made. If the rotor and case assembly is too tight in the cardan, it indicates either friction in the rotor case bearing, or too much tension on the torque motor actuating contact wiper. Slip-ring wipers must press firmly against the slip-ring, but not so tightly that they cause friction which will create too much resistance in the turning of the cardan. If the force required to turn the cardan gear is too high and there is a small amount of backlash between the cardan gear and the cardan drive pinion, check to make sure that the torque motor clutch discs are free from the clutch gear assemblies.

(16) CHECK ADJUSTMENT AND TENSION OF TORQUE MOTOR ACTUATING CONTACT WIPER.

(a) (See figure 265.) Test the bevel width on the wiper contact by turning the rotor case so that the bearing cap is facing the opening opposite the torque motor, and connecting the unit to a 26-volt d-c power source. Allow the gyro to run with torque motor on for one minute.

(b) Hold a rule near, but not touching, the rotor bearing cap, with one end resting on the stabilizer housing (figure 291). Slip the clutch drum over the upper cardan gudgeon pin, and gently attempt to turn the cardan in either direction. The rotor will tilt until

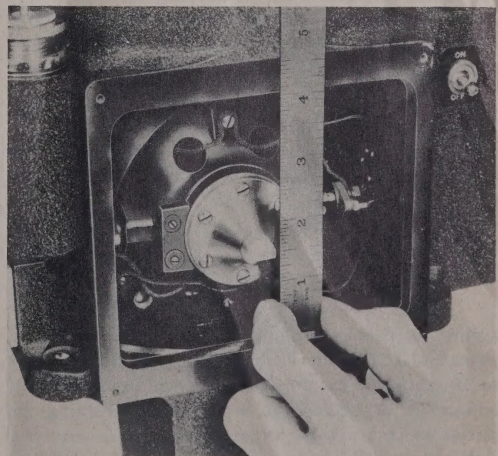


Figure 291 — Measuring Rotor Tilt

the wiper touches one of the inner segments of the contact block and brings the torque motor into play. Note the position of the bearing cap on the scale when this happens.

(c) Attempt to turn the clutch drum in the opposite direction. The rotor case will tilt until the contact wiper touches the other inner segment of the contact block. Take a new reading on the rule at this point.

(d) If the difference between the two readings is greater than $\frac{1}{4}$ -inch, one or both inner segments are dirty, the wiper contact is rounded, its flat surface is too narrow, the wiper blade is twisted, or the face of the wiper is rough. If the difference between the two readings is less than $\frac{1}{4}$ -inch, the flat surface of the wiper contact is too wide, or the bakelite gaps between the segments are filled with metal particles. If the faults indicated by this test cannot be remedied by cleaning the contact block, or by reshaping the wiper contact, the wiper or contact block (or both) must be replaced.

(e) Check to make sure that the wiper contact is in the exact center of the contact block when the rotor axis is exactly parallel to the mounting surface of the housing. To do this, use the rule held near, but not touching the rotor bearing cap, with one end resting on the stabilizer housing (as outlined above), and precess the gyro until the wiper touches one of the inner segments of the contact block and brings the torque motor into play just as before. Note the position of the bearing cap on the scale when this happens. (See figure 291.) Rotate the cardan so that the opposite rotor end cap will be at the housing opening, precess the gyro in the opposite direction, and note the position of the bearing cap on the scale when the torque motor comes into play. These readings should be exactly the same. If they are not, it indicates that the wiper contact is not centered on the contact block.

(f) To correct this, loosen the fillister-head screws attaching the contact assembly to the cardan, and slide it in the direction required. Repeat the test; if it is still not centered, an additional correction may be made by shifting the torque motor actuating contact wiper in the direction required. Difficulty in making this adjustment will result if the contact is not riding flat on the contact block.

(g) Check the pressure of the wiper contact against the contact assembly, using a gram gage. (See figure 292.) Tension on this wiper should be from 12 to 15 grams. If the tension is not within these limits, adjustment of tension can be made by loosening the screws which attach the wiper contact to the rotor case and slightly shifting the position of the wiper. Adjust these screws until the proper tension is attained.

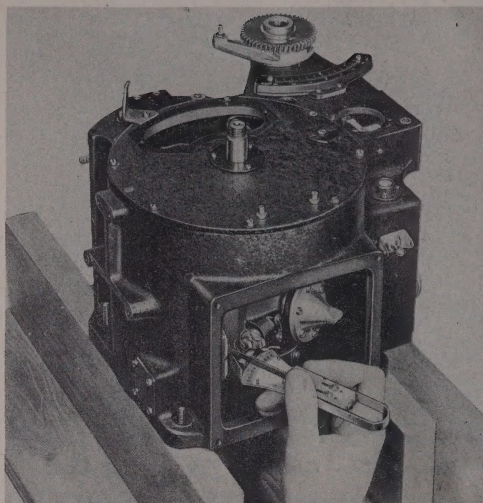


Figure 292 — Measuring Actuating Contact Wiper Tension

(17) INSTALL STABILIZER WINDOW AND TORQUE MOTOR COVER.

(a) Using three 3-48x $\frac{3}{8}$ -inch fillister-head screws, attach the directional indicator scale window to the housing.

(b) Using two 4-40x5/16-inch fillister-head screws and medium-spring lock washers, fasten the top housing cover inspection plate to the housing cover.

(c) Using four 4-40x $\frac{1}{4}$ -inch fillister-head screws with inner-tooth lock washers, attach the torque motor cover to the stabilizer housing. Use a small amount of sealing compound (U. S. Army Specification No. 2-87) under the edges of the cover.

(18) BALANCE THE ROTOR AND CASE ASSEMBLY IN THE CARDAN.

(a) SHAPE FLEX LEADS. (See figure 293.) Use a pair of tweezers to form the flex leads extending from the rotor case to the cardan. Form them carefully so that they contain no sharp bends and do not touch any portion of the cardan, the rotor case, or the housing throughout the full range of motion of the case in the cardan and the cardan in the housing.

(b) WARM UP THE GYRO FOR BALANCING.—Connect the stabilizer to a 26-volt d-c power source. Allow it to run for at least 1 $\frac{1}{2}$ hours so that it will reach its operating temperature. The stabilizer must be at operating temperature during the balancing procedure, because the rotor bearing on the side next to the torque motor actuating contact wiper is locked

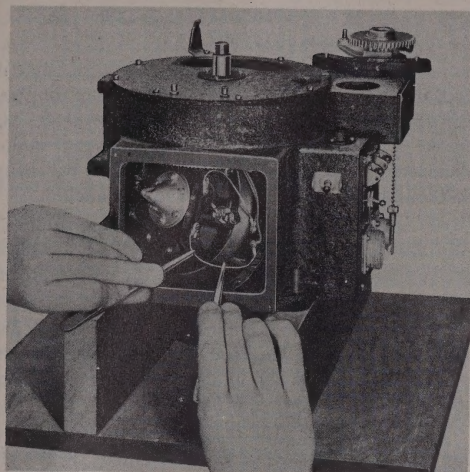


Figure 293 — Shaping Flex Leads

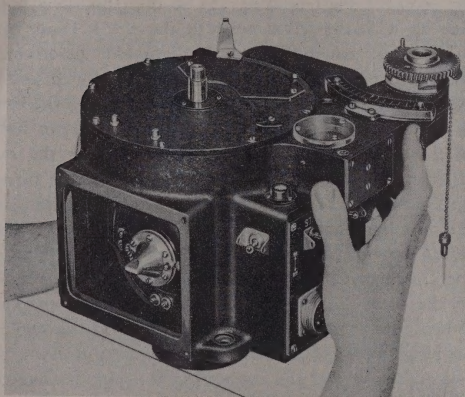


Figure 294 — Rocking to Determine Balance About Plane 1

to the case; as the rotor warms up, the metals expand and the center of weight of the rotor will move away from this locked bearing.

(c) **BALANCE THE ROTOR AND CASE ASSEMBLY ABOUT PLANE "2".** (See figure 296.)—As explained in the theory of balance, this section, paragraph 2, *b*, (2), the rotor and case assembly must be tested for balance about two perpendicular planes intersecting at right angles through the axis of the rotor case bearing. To balance the rotor and case assembly about plane 2, which is the horizontal plane through the rotor case bearings, it is necessary to

bring this plane into a vertical position by tipping the stabilizer up on the torque motor cover as shown in figure 296. With the stabilizer in this position and the rotor shaft in a vertical position, rock the case rapidly and evenly about the point at which the torque motor cover contacts the table. This will relieve the static friction on the rotor case bearings, and heaviness on either side of plane 2 will cause the rotor case to tip away from its vertical position. Add or remove weights at the points indicated in figure 297 to correct this unbalance, and recheck this balance about plane 2.

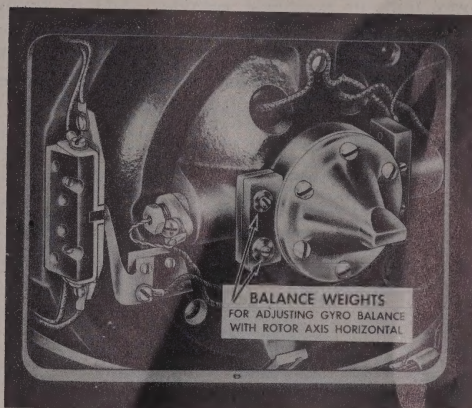


Figure 295 — Weights for Adjusting Balance About Plane 1

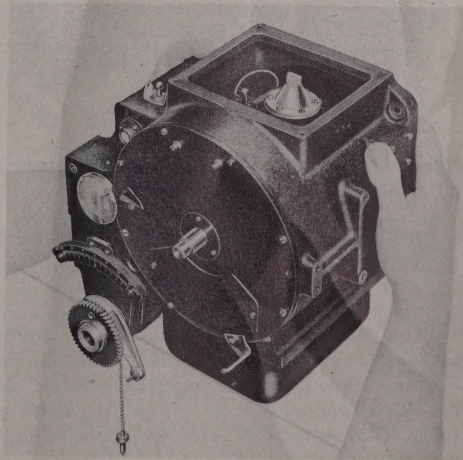


Figure 296 — Rocking to Determine Balance About Plane 2

Make the necessary corrections until the rotor and case assembly is exactly in balance about plane 2.

(d) **BALANCE THE ROTOR AND CASE ASSEMBLY ABOUT PLANE "1".** (See figure 294.)—To balance the unit about the vertical plane 1, place the stabilizer on the table, with one of the rotor case end caps toward the opening. Place the rotor and case assembly in a horizontal position; rock the case rapidly and evenly about the point where the housing rests on the table. This will relieve the static friction on the rotor case bearings, and heaviness on either side of plane 1 will cause the rotor case to tip away from its horizontal position. Add or remove weights from the balance screws indicated in figure 295, and recheck static balance about plane 1. Make the necessary weight adjustments to bring the rotor and case assembly into exact balance about plane 1.



Figure 297 — Adjusting Balance About Plane 2

(19) **ASSEMBLE AND INSTALL AUTOPILOT CLUTCH AND DRUM ASSEMBLY.**

(See figure 240.)

(a) Slip the autopilot clutch band (12) over the autopilot clutch drum (13) to which it was carefully fitted when these parts were inspected. Slip the autopilot clutch adjusting spring (16) and the clutch adjusting screw collar (17) over the clutch adjusting screw (15) so that the spring rests up against the knob on the screw. Then, screw the adjusting screw into the clutch band.

(b) **ADJUST AND INSTALL THE ECCENTRIC MECHANISM.**

(See figure 240.)

1. Insert the eccentric shaft (7) through the lock strip (6) and the shaft bushing (5). Slip the eccentric operating knob (2) over the top of the shaft. Line up the marks on the top of the eccentric shaft and on the operating knob; insert the dowel pin (1) far enough so that the shaft may be turned with the knob.

2. Screw the eccentric connecting rod (11) into the connecting rod nut (10) until the threads on the rod have almost come through the connecting rod nut.

3. Take two of the connecting rod nut links (9) and two connecting rod nut link pins (8), and, placing the links on top of the clutch band, insert the pins through the links and the clutch band (12).

4. Making sure that the side of the connecting rod (11) with the shoulder is down, lay the connecting rod and nut into the clutch band, and slip the assembled knob and eccentric on top of the band so that the eccentric enters the hole in the rod. Holding the eccentric shaft bushing (5) so that the screw holes line up with the screw holes in the clutch band, turn the knob so that the line on the knob and the eccentric shaft points toward the center of the clutch collar. Now swing the two links which are pinned to the band over the connecting rod nut, and see if the two holes in the links line up with the two holes in the nut. If this alignment is not correct, the nut must be turned up or down on the connecting rod to compensate for this misalignment. Repeat this alignment check, again lining up the holes in the bushing with the holes in the clutch band, and checking to see if the two holes in the links line up with the two holes in the nut. When correct alignment is obtained, drop the two remaining rod nut link pins (8) through the holes in the two top links and the connecting rod nut, remove the pin (1) and knob (2) so that the bushing (5), lock strip (6) and the eccentric shaft (7) may be fastened to the clutch band, using the two clutch eccentric stop screws (4) and two 3-48x5/16-inch fillister-head screws (3) in the holes, as shown.

5. Replace the knob on the eccentric shaft, and insert the dowel pin. Test to see if the clutch releases properly. With the knob in the engaged position, the connecting rod nut link pins (8) should be free and easily inserted, or removed. With the knob in the disengaged position, the clutch band should slide freely over the clutch drum. If either of these two conditions do not exist, further adjustment between the connecting rod and the connecting rod nut is necessary.

6. After checking for proper operation, install the two remaining connecting rod nut links (9) over

connecting rod pin through the loop so that the spring scale may be hooked around the pin or to the loop. Attach the spring scale and measure the force required to slip the clutch. Apply the force at the radius of the stud ($3\frac{1}{2}$ -inches) to which the connecting rod is attached.

(c) With the bombsight clutch disengaged, the clutch should move freely on its drum in any position. If this test cannot be passed, there is evidence of excessive wear in any one or all of the following parts: the eccentric, the toggle gudgeon, the eccentric locating holes and pivot pin hole in the clutch collar, the pivot link pin. If such excessive wear is apparent, all worn parts should be replaced.

(d) With the bombsight clutch engaged, the clutch should not slip until from 18 to 24 pounds have been exerted by means of the spring scale. If the force registered by the spring scale is less than 18 pounds, screw up on the adjusting knob to increase the tension. If the force is more than 24 pounds, unscrew the adjusting knob to decrease the tension. If increasing the spring loading to a maximum by means of the adjusting knob does not bring the force required to slip the clutch within the prescribed limits (18 to 24 pounds), the tension spring is defective or there is excessive wear on the

bombsight clutch drum or both. Replacement of worn parts is required.

(22) CHECK TENSION AND ADJUSTMENT OF AUTOPILOT CLUTCH.

(a) (See figure 299.) Insert a block through the opening covered by the name plate side cover assembly to prevent the cardan from turning, so that the tension of the autopilot clutch assembly may be tested.

(b) (See figure 301.) Form a loop of cord around the connecting arm pin. Attach a spring scale to the cord and measure the force required to slip the autopilot clutch at the radius of the stud to which the connecting rod is attached (2 inches).

(c) (See figure 302.) With the clutch in the engaged position, screw up on the adjusting knob until the pull required to slip the clutch is from 10 to 12 pounds. Again test the clutch in four different positions to make sure that this same pull is required to slip the clutch at four different points equally spaced around the circumference. Any great variation in the pull required at various points around the circumference indicates that the clutch band is not properly fitted to the drum, and the parts should be replaced.

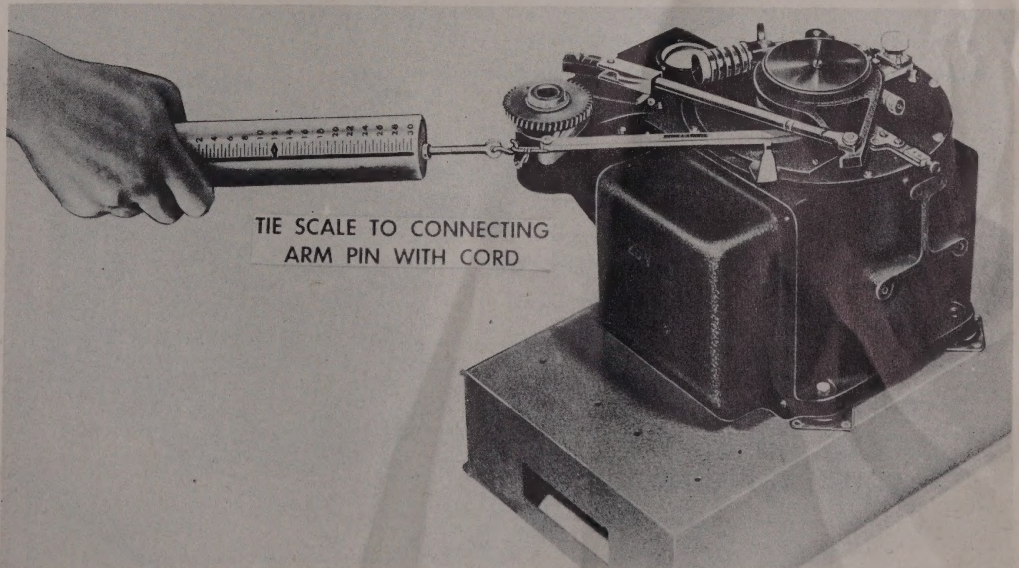


Figure 301 — Testing Autopilot Clutch Tension

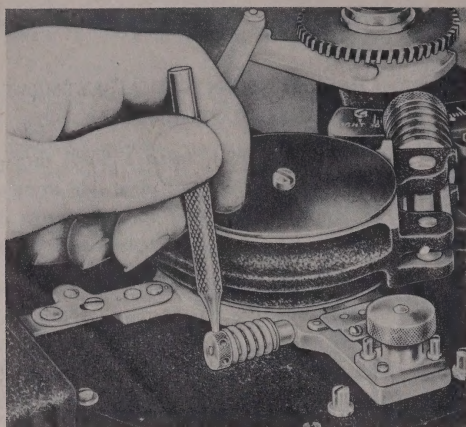


Figure 302 — Adjusting Autopilot Clutch Tension

(23) CHECK ADJUSTMENT OF DRIFT GEAR CLUTCH.

(a) (See figure 303.) Form a loop of cord around the stud on the drift clutch arm so that a spring

scale may be hooked to the cord for measuring the force required to slip the drift gear clutch at this radius.

(b) Be sure autopilot clutch is disengaged. Hold the drift gear firmly with the hand while pulling the spring scale. The drift gear clutch should slip when subjected to a force of between six and eight pounds. Adjust the tension of the drift gear clutch if necessary by turning the tension adjusting screw. If it is impossible to apply sufficient tension to obtain this required pull at this radius, either the spring or the collar must be replaced.

(24) TEST STABILIZER FOR PRECESSION.

(a) Connect a 26-volt d-c source to the stabilizer and warm up the gyro for 1 hour and 30 minutes with the torque motor running.

(b) Disengage the autopilot clutch, set the pilot's directional indicator wiper at zero on the scale, and then engage the autopilot clutch. The pilot's directional indicator wiper should drift not more than $\frac{1}{4}$ degree in 30 minutes of operation. If the wiper drifts

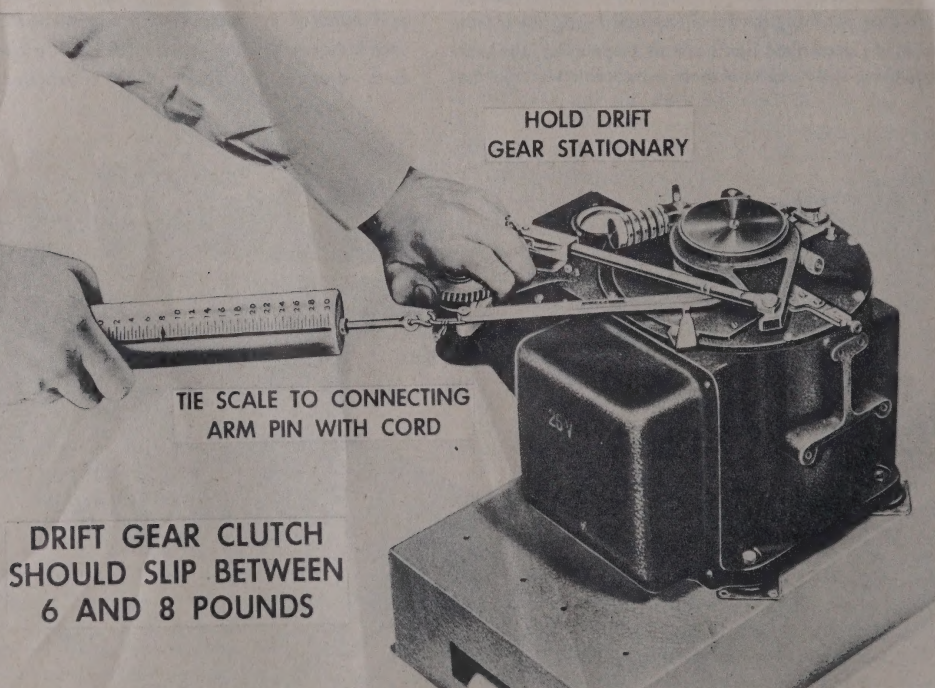


Figure 303 — Testing Drift Gear Clutch Tension

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
BRUSH WEAR EXCESSIVE.	Rough commutator.	Dress.
STATIC BALANCE OF ROTOR AND CASE SHIFTS.	Rotor is not locked in case.	Lock rotor with proper shim. (Refer to this section, paragraph 3, e, (8).)
	Locked rotor bearing has too much end play.	Replace with good bearing. (Refer to this section, paragraph 3, e, (8).)
DIRECTIONAL STABILIZER DOES NOT HOLD PILOT'S DIRECTIONAL INDICATOR ON CENTER WHEN TORQUE MOTOR IS RUNNING.	Dynamic unbalance.	Rebalance. (Refer to this section, paragraph 3, e, (18).)
	Static unbalance.	Rebalance. (Refer to this section, paragraph 3, e, (18).)
	Dirty or damaged tilt axis bearings.	Clean, or replace bearings.
DIRECTIONAL STABILIZER DOES NOT HOLD PILOT'S DIRECTIONAL INDICATOR ON CENTER WHEN TORQUE MOTOR IS RUNNING.	Rotor and case-to-cardan bearings too tight in socket.	Refit bearing to socket.
	Locking screw long enough to touch bottom of counterbore in rotor case.	Shorten screw.
	Insufficient end play on tilt axis.	Use shim between gudgeon and counterbore in cardan.
	Torque motor clutches exert unequal torque.	Adjust torque motor torque of both clutches to 112 to 126 inch-pounds.
	Torque motor clutches grab.	Clean cork insert on clutch gear and surface of clutch and pinion assembly.
ROTOR WILL NOT TURN.	Bad switch.	Replace.
	Bad lead wire connections.	Repair.
	Brushes not making contact.	Increase tension.
	Burned-out field.	Replace.
	Burned-out armature.	Replace.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
TORQUE MOTOR WILL NOT TURN.	Bad switch.	Replace.
	Bad lead wire connections.	Repair.
	Brushes not making contact.	Increase tension.
	Burned-out field or armature.	Replace.
TORQUE MOTOR WILL NOT COME UP TO SPEED.	Bad bearings.	Replace.
	Low brush tension.	Readjust to 3 to 3½ ounces.
	Bad mesh between any one pin ion and gear.	Replace worn parts.
	Commutator dirty.	Clean.
TORQUE MOTOR DOES NOT EXERT SUFFICIENT TORQUE.	Defective torque motor.	See remedy above for torque motor which does not turn or come up to speed.
	Burned-out clutch coils.	Replace.
	Air gap on clutches too great.	Milling or filing down the thrust button thickness.
	Dirty cork surface on clutch gear.	Clean. (Refer to this section, paragraph 3, <i>d</i> , (7).)
	Worn cork.	Replace cork and gear assembly.
CORRECTIVE CLUTCH ACTION OF TORQUE MOTOR IS NOT CALLED FOR WITHIN THE LIMITS OF $\pm 1^\circ$ FOR ½ VOLTAGE, NOR $\pm 3^\circ$ FOR FULL VOLTAGE FROM HORIZONTAL.	Contact point and actuating contact surface dirty.	Clean with carbon tetrachloride.
	Contact point not riding flatly on contact surface.	Adjust. (Refer to this section, paragraph 3, <i>e</i> , (16).)
	High spots on surface of actuating contact block.	Polish down high spots with fine polishing cloth.
	Insufficient tension on contact wiper arm.	Increase to from 12 to 15 grams.
TORQUE MOTOR CORRECTIVE CLUTCH ACTION IS IN WRONG DIRECTION.	Lead wires to No. 3 and 4 slipping brushes reversed.	Reverse lead wires.
CORRECTIVE CLUTCH ACTION OF TORQUE MOTOR IS NOT CALLED FOR EVEN WHEN GOOD CONTACT BETWEEN WIPER AND BLOCK IS MADE.	Bad resistance coil.	Replace resistance coil.
	Bad contact between lead wires and terminal points.	Clean contact surface with abrasive, or replace with new lead wires.

4. DIRECTIONAL PANEL.

a. GENERAL.

(1) The directional panel mounts on the side of the stabilizer assembly so that the rounded end of the directional drive arm on the stabilizer autopilot clutch assembly enters the hole in the directional panel slide. Thus the directional panel is actuated by the stabilizer.

(2) The directional panel is considered as a separate assembly because it may be readily removed from the stabilizer and overhauled as a separate unit.

b. OVERHAUL TOOLS REQUIRED.

(1) The following special tools should be available for use in disassembly, inspection, repair and re-assembly of the directional panel in addition to an assortment of standard tools, such as screw drivers, pliers, wrenches, etc.

(2) SPECIAL TOOLS.

<i>Nomenclature</i>	<i>Application</i>
0-50 Gram Gage	Testing wiper and contact tension.
0-10 Gram Gage	Checking rudder potentiometer wiper tension.
Thickness Gage	Setting erecting cutout switch and rocker arm assembly.

c. DISASSEMBLY.

(1) REMOVE DASH POT

ASSEMBLY. (See figure 305.)

(a) Lift the link pin retaining spring slightly and turn the spring out of the way so that the connecting rod link pin which connects the dash pot piston rod assembly (2) to the dash pot actuating lever assembly (1) may be withdrawn.

(b) Remove the three fillister-head screws which attach the dash pot assembly (3) to the housing (4) and remove the dash pot assembly.

(2) DISASSEMBLY DASH POT

ASSEMBLY. (See figure 306.)

(a) Unscrew the cylinder assembly (2) from the housing assembly (4) and remove the cylinder locking nut (3) from the cylinder assembly.

Note

Do not attempt to remove the collar from the cylinder. If either collar or cylinder is damaged, they must be replaced as an assembly.

(b) Pull the piston assembly (1) out of the cylinder assembly. The anti-splash cover assembly fits

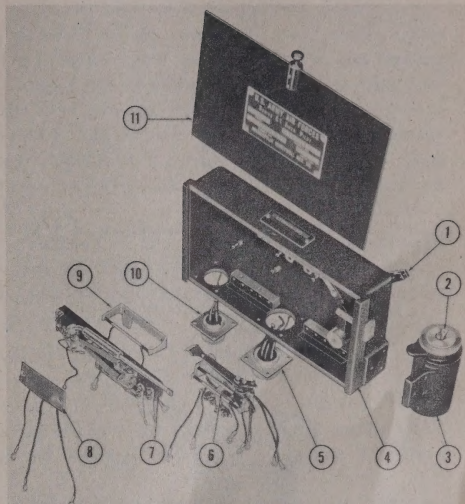


Figure 305 — Directional Panel, Exploded View

<i>Index No.</i>	<i>Nomenclature</i>
1.	Actuating Lever Assembly
2.	Dash Pot Piston Rod Assembly
3.	Dash Pot
4.	Housing
5.	AN Receptacle
6.	Banking Potentiometer Assembly
7.	Rocker Arm Mounting Block Assembly
8.	Resistor Card Assembly
9.	Rudder Potentiometer Assembly
10.	AN Receptacle
11.	Slide Cover Assembly

tightly into the cylinder assembly but will come loose if the piston assembly is pulled against it sharply.

Note

Do not attempt to disassemble the piston assembly unless absolutely necessary. These parts are carefully fitted together and pinned with small dowel pins which are inserted in holes drilled during assembly and crushed into place. Only the cotter pin, piston rod valve spring collar, piston rod valve spring, and piston may be removed without damaging the assembly. It is recommended, however, that not even these parts be disassembled and the entire assembly be replaced if any parts are damaged or if it does not function properly.

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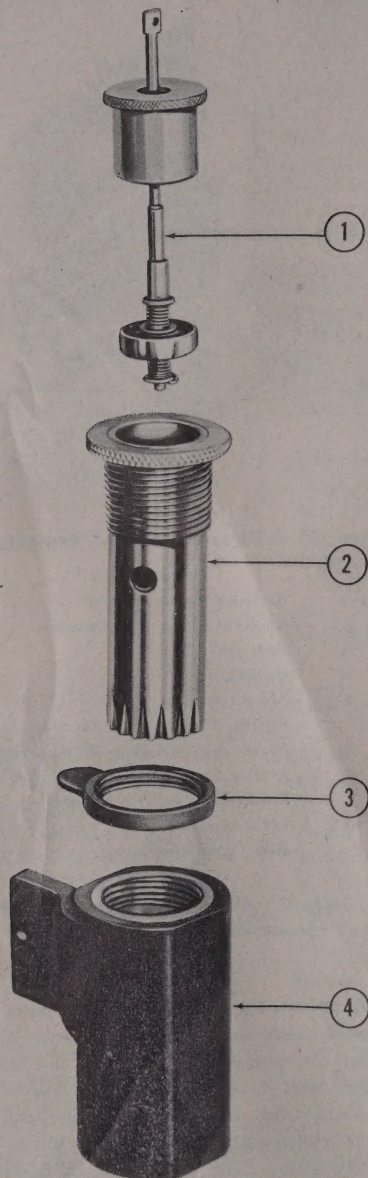


Figure 306 — Dash Pot, Exploded View

Index No.	Nomenclature
1.	Piston Assembly
2.	Cylinder Assembly
3.	Locking Nut
4.	Housing Assembly

(3) REMOVE AND DISASSEMBLE
COVER ASSEMBLY. (See figure 305.)

(a) Slide the cover assembly (11) from the housing by grasping the knob and pulling the cover up out of the slot in the housing.

(b) Remove the cover knob from the housing by removing the two flathead screws which attach it to the cover.

(4) REMOVE POTENTIOMETER
WIPER ASSEMBLIES. (See figure 307.)

(a) Remove the two binding-head screws which attach the rudder potentiometer wiper assembly (1) and the wiper holder plate (2) to the rocker arm assembly. A plain washer is found under the right-hand binding-head screw, and over the lug of the short flex lead (16). Remove wiper assembly and wiper holder plate.

(b) Remove the fillister-head screws, plain washers, and two-hole washers which secure the banking potentiometer wiper assemblies (9 and 10) to the rocker arm mounting block assembly (4), and remove the wiper assemblies.

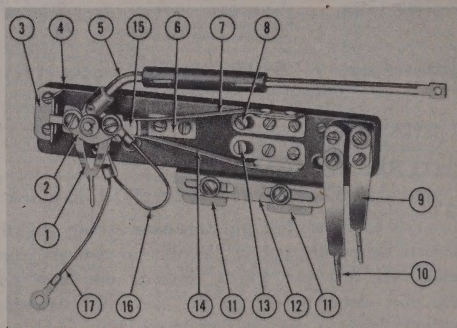


Figure 307 — Rocker Arm Mounting Block Assembly

Index No.	Nomenclature
1.	Potentiometer Wiper Assembly
2.	Wiper Holder Plate
3.	Rocker Arm Stop Bracket
4.	Mounting Block Assembly
5.	Connecting Arm Assembly
6.	Spring Stop
7.	Spring Bracket Assembly
8.	Eccentric Screw
9.	Right-Hand Potentiometer Wiper Assembly
10.	Left-Hand Potentiometer Wiper Assembly
11.	Operating Cams
12.	Switch Cam Bracket Assembly
13.	Eccentric Screw
14.	Spring Bracket Assembly
15.	Rocker Arm Assembly
16.	Flex Lead—2 inch
17.	Flex Lead—3 inch

(5) REMOVE THE TWO AN RECEPTACLE ASSEMBLIES. (See figure 305.)

(a) Remove the eleven binding-head screws which attach all of the lead wire terminal lugs to the terminal blocks.

(b) Remove the four fillister-head screws which attach each AN receptacle assembly to the housing, and remove the AN receptacle assemblies (5 and 10).

CAUTION

In removing AN receptacle assemblies, be careful that the lead wire lugs do not come in contact with the potentiometer windings.

(6) REMOVE THE ROCKER ARM MOUNTING BLOCK ASSEMBLY. (See figure 305.)—Lift the link pin retaining spring on the dash pot actuating bell crank assembly and rotate the spring out of the way so that the bell crank connecting rod link pin may be pulled out of place to disconnect the bell crank connecting rod from the bell crank assembly. Remove the two screws which attach the mounting block to the slide and remove the block assembly.

(7) DISASSEMBLE ROCKER ARM MOUNTING BLOCK ASSEMBLY. (See figure 307.)

(a) Remove the round-head screw and spring lock washer which secure the terminal lugs of the two flex leads (16 and 17) attached to the mounting block (4) and remove the flex leads.

(b) Remove the two fillister-head screws which secure the rocker arm stop bracket (3) to the mounting block and remove the stop bracket.

(c) Remove the four fillister-head screws which secure the left-hand and right-hand rocker arm centering spring bracket assemblies (7 and 14) to the mounting block and remove the centering spring bracket assemblies.

(d) Remove the two fillister-head screws which secure the spring stop (6) to the block and remove the centering spring stop.

(e) Remove the two fillister-head screws which secure the erecting cut-out switch cam bracket assembly (12) to the mounting block and remove this assembly. The two erecting cut-out switch operating cams (11) may be removed from the switch cam mounting bracket by removing the two binding-head screws and plain washers which secure them to the bracket.

(f) Remove the snap ring and spacing washer which secure the rocker arm assembly (15) to the rocker arm pivot stud on the mounting block, and remove the rocker arm assembly.

Note

Do not attempt to disassemble the rocker arm assembly. If any part of this assembly is damaged, the entire assembly should be replaced.

(8) REMOVE POTENTIOMETER ASSEMBLIES. (See figure 305.)

(a) Remove the two fillister-head screws which secure the resistor card assembly (8) to the housing (4). Remove the two fillister-head screws which secure the dual banking potentiometer assembly (6) to the housing, and remove the dual banking potentiometer assembly and the resistor card assembly. Also remove the two spacers under the resistor card assembly.

(b) Remove the remaining fillister-head screw which attaches the rudder pick-up potentiometer assembly (9) to the housing, and remove the rudder pick-up potentiometer.

(9) DISASSEMBLE THE DUAL BANKING POTENTIOMETER ASSEMBLY. (See figure 308.)

(a) Remove the two fillister-head screws which secure the erecting cut-out switch blade assemblies

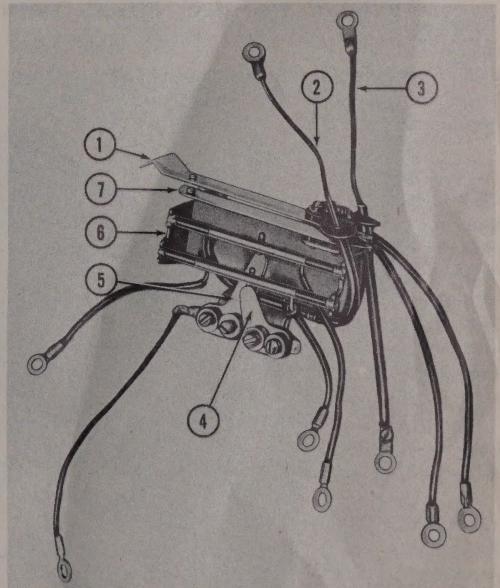


Figure 308 — Dual Banking Potentiometer Assembly

Index No.	Nomenclature
1.	Cutout Switch Blade
2.	Flex Lead
3.	Flex Lead
4.	Potentiometer Center Contact Assembly
5.	Potentiometer Center Contact Assembly
6.	Potentiometer Mounting Assembly
7.	Cutout Switch Blade

(1 and 7) to the dual banking potentiometer mounting bracket (6). When these two screws and all parts they attach are removed together the following parts may be removed from the screws in the following order: two insulating bushings, erecting cut-out switch stationary blade assembly, two 2-hole insulators, erecting cut-out switch actuating blade assembly, two additional insulating bushings, two lead wire holders, and two plain washers.

(b) Remove the two fillister-head screws which hold each potentiometer center contact assembly (4 and 5) to the mounting bracket (6) and remove the following parts from each pair of screws in the following order: one 2-hole insulator, the center contact assembly, two insulating bushings, a 2-hole washer, and two medium-spring lock washers. One of the lead wires from the resistor card assembly may be soldered to the right-hand contact assembly (4) (if there are only five terminals on the right-hand terminal block) and need not be unsoldered unless the resistor card or the contact assembly is to be replaced.

(10) REMOVE TERMINAL BLOCKS FROM HOUSING. (See figure 309.)—Remove the four fillis-

ter-head screws which attach the two terminal blocks (13) to the housing, and remove the terminal blocks and the insulating strips (12) between the terminal blocks and housing (3).

(11) REMOVE THE DASH POT
ACTUATING BELL CRANK
ASSEMBLY. (See figure 309.)

(a) Using a small punch and light hammer, tap out the taper pin which secures the dash pot actuating lever (1) to the dash pot actuating lever shaft (7). Remove the lever from the lever shaft.

(b) Remove the three fillister-head screws which attach the dash pot actuating lever shaft ball bearing cap (2) to the housing (3) and remove the ball bearing cap. This will permit the inside end of the shaft to be removed from the hole in the supporting post (4) and the shaft may be withdrawn from the housing.

(c) Remove the actuating lever shaft bearing (5) and spacer (6) from the shaft. If the bearing was removed with the bearing cap it may be tapped out of the cap with pins inserted through the holes provided. With a small drift pin and light hammer,

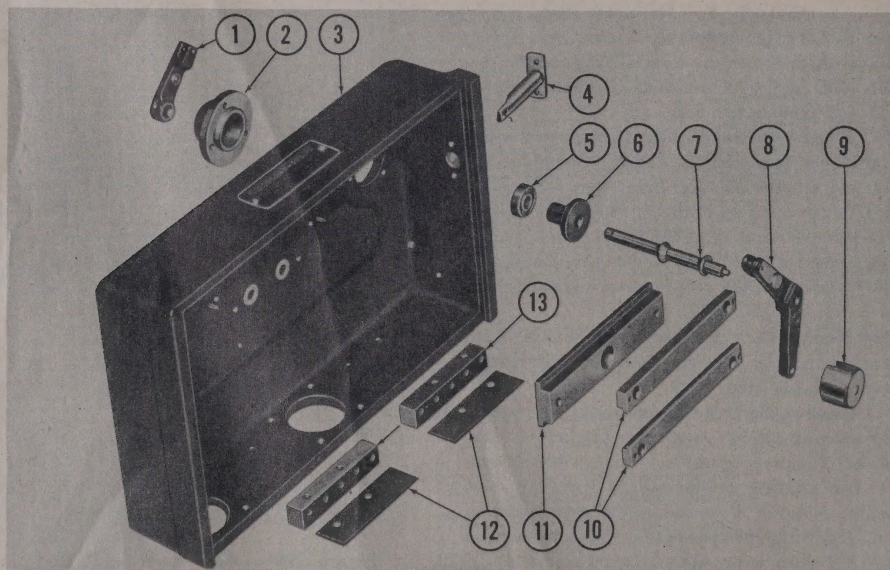


Figure 309 — Directional Panel Housing Assembly, Exploded View

Index No.	Nomenclature
1.	Dash Pot Actuating Lever
2.	Ball Bearing Cap
3.	Housing Assembly
4.	Lever Shaft Supporting Post
5.	Lever Shaft Bearing
6.	Spacer
7.	Actuating Lever Shaft

Index No.	Nomenclature
8.	Bell Crank Assembly
9.	Bell Crank Counterweight
10.	Operating Slide Guides
11.	Operating Slide
12.	Insulating Strips
13.	Terminal Blocks

loosen the tapered pin which secures the bell crank assembly (8) to the actuating lever shaft (7). Remove the bell crank assembly from the actuating lever shaft.

(d) Remove the fillister-head screw which secures the bell crank counterweight (9), to the bell crank assembly and remove the counterweight.

(e) Do not attempt to disassemble the bell crank assembly further; if any of the other parts of the bell crank assembly (8) or of the actuating lever assembly (1), such as the retaining springs, are damaged, replace the entire assembly.

(f) Remove the two fillister head screws which secure the actuating lever shaft supporting post (4) to the housing and remove the supporting post.

(12) DISASSEMBLE HOUSING ASSEMBLY. (See figure 309.)—Scribe the slide guides and slide so that they may be reassembled in the same position. Remove the four fillister-head screws which secure the operating slide guides (10) to the housing and remove the two operating slide guides and the operating slide (11). Carefully remove any shims found under the guides.

d. CLEANING, INSPECTION, TESTING AND REPAIR.

(1) VISUAL EXAMINATION.—Examine all parts for noticeable damage of any kind. Replace any damaged parts.

(2) HOUSING ASSEMBLY. (See figure 309.)—Wash the housing (3), slide (11), and slide guides (10) in carbon tetrachloride (U.S. Army Specification No. 4-503-110B). Examine the slide and slide guides and the housing where the slide bears against it for nicks or scratches which might prevent the free sliding of the slide in the guide against the housing. Polish out any fine nicks or scratches with a fine India stone or very fine polishing cloth. If nicks or scratches are deep, replace the damaged part. Be sure that dowel pins are not bent or damaged.

(3) AN RECEPTACLES AND TERMINAL BLOCKS.

(a) Examine AN receptacles carefully and the wires attached to them. If wire insulation is broken or soldered connections seem loose, solder new lead wires in place. If receptacle is damaged or pins are blackened replace receptacle. Check all soldered connections to each AN receptacle with an ohmmeter, flexing the lead slightly so that any breaks in the wires or loose solder connections will cause a movement of the ohmmeter needle. Resolder any faulty connections.

(b) Examine terminal blocks carefully for cracks or stripped threads and if damage of this kind is detected, replace the terminal blocks.

(4) DUAL BANKING POTENTIOMETER ASSEMBLY. (See figure 308.)

(a) Dampen a clean white cloth with carbon tetrachloride (U.S. Army Specification No. 4-503-110B) and clean the two potentiometers carefully, polishing them with a clean dry white cloth. Check the resistance from one end to the other of each potentiometer, using an ohmmeter. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. These potentiometers are each designated as R10 and R11 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the potentiometer assembly. Use the ohmmeter to check for resistance at the points where lead wires are soldered to the windings to determine any break in the soldered connection or break in the lead wire. Flex the lead wire slightly so that any breaks will cause fluctuation of the ohmmeter needle. Also examine lead wires for damaged insulation and, if any damage or breaks are detected, replace the bracket and potentiometer assembly.

(b) Clean the contacts on the erecting cut-out switch blade assemblies (1 and 7) with a very fine polishing cloth, being careful to polish only enough to make sure that contacts are clean and bright. If either blade assembly is bent out of shape or the contacts damaged, replace the assembly.

(c) Examine both center tap contact assemblies (4 and 5), and if either assembly is bent or damaged, replace the assembly. If contacts are not clean and bright, polish lightly with a very fine polishing cloth. Use an ohmmeter to make sure that there are no breaks in the lead wires or in the soldered connection to the assemblies. Flex the wires slightly when the ohmmeter is connected between the contact assembly and the lead wire terminal lug; if any fluctuation on the ohmmeter needle is detected, replace the contact assembly or resolder the loose connection.

(d) Examine all insulating washers and insulating bushings carefully and replace any that appear to be damaged.

(5) RUDDER PICK-UP POTENTIOMETER ASSEMBLY. (See figure 305.)—Clean the potentiometer winding with a cloth moistened with carbon tetrachloride (U.S. Army Specification No. 4-503-110B) and then polish with a clean white cloth. Check the resistance of the potentiometer winding with an ohmmeter. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. This potentiometer is designed as R9 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the potentiometer assembly. Use the ohmmeter to check each lead wire and soldered connection to the potentiometer winding. Flex the wire slightly when the ohmmeter is con-

ected, and if any fluctuation of the ohmmeter needle is detected, replace the potentiometer assembly.

(6) RESISTOR CARD ASSEMBLY. (See figure 305.)

(a) Test the resistance of each winding in the resistor card (8) with an ohmmeter. This is done by connecting one lead of the ohmmeter to the center lead from the resistor card and touching the other ohmmeter lead first to the lead wire from one end of the card and then to the lead from the other end of the card. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. These two resistances are designated as R12 in the table. If resistance of either is found to be outside of the limits prescribed in the table, replace the resistor card assembly.

(b) Flex the lead wires slightly while the ohmmeter is connected to detect any breaks in the lead wires. If any lead wire breaks are indicated by fluctuation of the ohmmeter needle, replace the resistor card assembly.

(7) ROCKER ARM MOUNTING BLOCK ASSEMBLY. (See figure 307.)

(a) Examine the rocker arm mounting block assembly carefully for cracks or stripped threads. If either are detected, replace the block assembly. Make sure that the rocker arm pivot stud is not bent or damaged. Check the rocker arm centering spring eccentric screws (8 and 13) to see that they are firmly in place and are not loose on the block. If any damage is detected, replace the assembly.

(b) Check the rocker arm stop bracket (3) for bends and straighten if necessary. Also check the erecting cut-out switch cam bracket assembly; and if the bracket (12) or cams (11) are damaged, replace the assembly. Examine each cam carefully to make sure that there are no burrs on the corners which contact the erecting cut-out blade assembly.

(c) Examine both left-hand and right-hand rocker arm spring bracket assemblies (7 and 14) and, if either the springs or brackets are bent out of shape, replace the assemblies.

(d) Test the fit of the rocker arm assembly (15) on the rocker arm stud to make sure that it fits snugly but is free to turn easily. If any binding is detected, polish the stud down slightly so that the rocker arm turns freely on the stud.

(e) Examine the three wiper assemblies (1, 9, and 10) carefully and, if they are bent or damaged, replace them. If contacts are not clean and bright, polish with a very fine polishing cloth.

(f) Check the connecting arm assembly (5) to make sure that it is not damaged. The alignment of this arm can only be checked after assembly.

(g) Use an ohmmeter to check the two flex leads (16 and 17) which attach to the rocker arm mounting block assembly, flexing the leads to detect any break in the leads. Replace any leads which are frayed or broken.

(8) ACTUATING LEVERS AND SHAFTS. (See figure 309.)

(a) Inspect, wash and lubricate the ball bearing in accordance with instructions outlined in this section paragraph 2, d, (1) and (2).

(b) Carefully check the fit of the bearing (5) on the actuating lever shaft (7) and in the bearing cap (2). The bearing should fit snugly on the shaft and in the cap, but not so tightly that it cannot be pushed into place with the fingers.

(c) Examine the actuating lever shaft spacer (6) carefully to see that it is not cracked. If it is cracked or damaged in any way, replace the spacer.

(d) Examine the shaft (7) carefully to make sure that it is not bent and that it fits snugly into the actuating lever assembly and into the actuating bell crank assembly.

(e) Examine the actuating lever assembly (1) and the actuating bell crank assembly (8) carefully and also the lever shaft supporting post. Pay particular attention to the retaining springs on these two assemblies and, if the retaining springs are damaged, replace the assembly.

(f) Check the link pins carefully to see that they fit snugly in the actuating lever assembly, and the bell crank assembly, and also into the connecting rod and piston rod assembly. If they do not fit snugly but without binding, replace the pins.

(9) DASH POT ASSEMBLY. (See figure 306.)

(a) Examine the dash pot housing assembly (4) and the dash pot cylinder assembly (2) for any noticeable damage. Pay particular attention to the polished inside surfaces of the cylinder assembly. If these surfaces are scratched, replace the cylinder assembly. No attempt should be made to remove the collar from the cylinder. If either are damaged, replace the assembly.

(b) Wash the housing assembly and the cylinder assembly carefully in carbon tetrachloride (U.S. Army Specification No. 4-503-110B) and coat the polished surfaces of these assemblies with a fine film of oil to prevent rust (Army Air Force Specification 3582-A).

(c) No disassembly procedure was given for disassembling the piston assembly (1). This assembly should not be disassembled unless it is damaged and no replacement assembly is available. An exploded view of the piston assembly is shown in figure 310 to show all of the various parts which go to make up the cover assembly and the rod assembly. This assembly

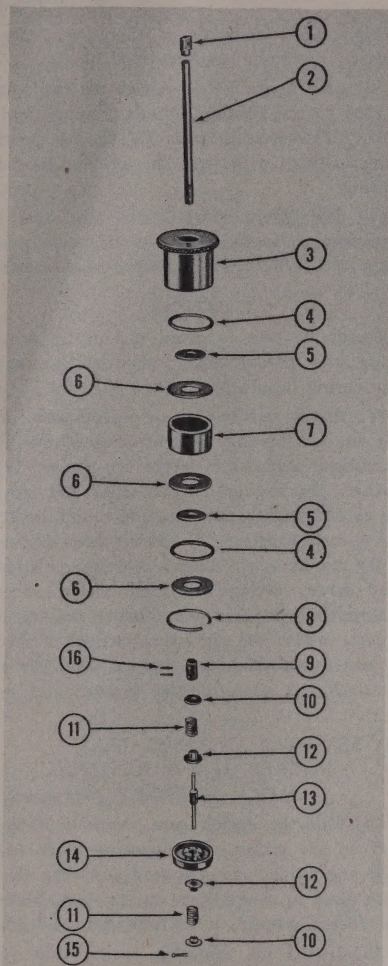


Figure 310 — Dash Pot Piston Assembly,
Exploded View

Index No.	Nomenclature
1.	Piston Rod Link
2.	Piston Rod
3.	Anti-Splash Cover
4.	Short Spacing Sleeve
5.	Small Washer
6.	Large Washer
7.	Long Spacing Sleeve
8.	Lock Ring
9.	Piston Rod Sleeve
10.	Piston Rod Valve Spring Collar
11.	Valve Spring
12.	Relief Valve
13.	Rod
14.	Piston
15.	Cotter Pin
16.	Dowel Pins

should not be disassembled because the two dowel pins are crushed into place in the connecting rod with an arbor press and, therefore, cannot be removed without damaging the parts. The piston rod extension is soldered to the upper end of the piston rod, and therefore, cannot readily be removed to permit the removal of the cover assembly.

(d) Wash the piston assembly carefully in carbon tetrachloride (U.S. Army Specification No. 4-503-110B) and blow out the holes in the piston with filtered compressed air. These holes serve as release valve ports for the dash pot and, therefore, must be clean if the dash pot is to operate properly.

(e) An actual check of the dash pot assembly will be made in the reassembly procedure at which time it will be possible to determine if the dash pot will operate satisfactorily. No actual check of this operation can be made until it is assembled.

e. REASSEMBLY.

(1) ASSEMBLE HOUSING ASSEMBLY AND ACTUATING SHAFT AND LEVERS. (See figure 309.)

(a) Line up scribe marks and secure the two operating slide guides (10) to the housing using four 3-48 x 1/4 inch fillister-head screws taking care that these guides fit properly over the dowel pins in the housing. If either the slides or guides have been replaced, it may be necessary to remove dowel pins from the housing and redrill for new dowels after properly locating the slides and guides. Be sure to cover the slide (11) with a thin film of oil and put it in place before installing the second guide. Replace any shims removed from under the guides in the position from which they were removed.

Note

Dowel pin holes are drilled with a No. 53 drill and holes in the guides are reamed to .0620 inches.

If attaching screws project through the back of the housing, file off the ends of the screws so that they do not project.

(b) Tip the housing assembly 45 degrees on either side and check to see that the slide falls of its own weight to the end of the housing. If the slide does not move freely on this test, check for cause of binding and stone down with a fine India stone if necessary or use shims under the guides to give the required fit. (.002 to .005 inch clearance between slide and housing should be provided.)

(c) Insert dash pot actuating lever shaft supporting post (4) through the hole in the housing assembly (3) and secure it to the housing assembly, using two 3-48 x 1/4-inch fillister-head screws.

(d) Secure the bell crank assembly (8) to the

actuating lever shaft (7) taking care that the tapered pin is inserted properly in the tapered holes in the bell crank and shaft. Seat the pin securely with a drift punch and light hammer. Attach the counterweight (9) to the bell crank assembly with a 3-48 x $\frac{3}{8}$ inch fillister-head screw.

(e) Remove the ball bearing (5) from its covered container (into which it was placed after it was cleaned and lubricated) and slip the spacer (6) and ball bearing on the actuating shaft. Insert the actuating lever shaft through the hole in the housing and then place the small end of the shaft next to the bell crank into the hole provided in the supporting post.

(f) Slip the ball bearing cap (2) over the ball bearing and secure the cap to the housing using three 3-48 x $\frac{3}{8}$ -inch fillister-head screws. The cap must fit flush against the housing. There must be free movement of the bell crank and lever assembly. Check end play of the shaft to see that it does not exceed 1/64-inch. Place the actuating lever assembly (1) on the end of the shaft, taking care to line up the holes for the tapered pin carefully and drive the tapered pin securely into place, being careful to support the lever assembly so that the ball bearing is not damaged.

(2) ASSEMBLE AND INSTALL POTENTIOMETER ASSEMBLIES.

(a) (See figure 308.)—Install the erecting cut-out switch assembly on the dual banking potentiometer mounting bracket, slipping the following parts in the following order over the two 2-56 x $\frac{7}{8}$ -inch fillister-head screws: a spring lock washer on each screw, a 2-hole washer, two lead wire holders (holders face in opposite directions), two insulating bushings (with small diameter away from head of screw), erecting cut-out switch actuated blade assembly (1) (with contact away from head of screws), two 2-hole insulators, erecting cut-out switch stationary blade assembly (7) with contact point toward head of screws), two insulating bushings (with small diameters toward head of screws). Secure this assembly to the mounting bracket.

(b) Install the dual banking potentiometer center contact assemblies (4 and 5) to the bracket using two 2-56 x $\frac{1}{4}$ -inch fillister-head screws for each contact assembly with a spring lock washer, a flat washer, insulating bushings (with small diameter away from head of screw) over the contact assembly and a two-hole insulator under each contact assembly.

(c) Make sure that all lead wire connections to the dual banking potentiometer assembly are soldered securely in place and place the tubing covered flex leads (2 and 3) into the lead wire holders. Make sure that the flex lead (2) from the potentiometer is in the upper lead wire holder, and that the lead wire from the resistor card assembly is properly soldered to the

right-hand contact assembly if there are only five terminals on the right hand terminal block.

(d) (See figure 309.)—Attach the two terminal blocks (13) to the housing assembly, using four 3-48 x $\frac{1}{2}$ -inch fillister-head screws. Be sure to insert the insulating strips (12) between the terminal blocks and the housing.

(e) (See figure 305.)—Attach the dual banking potentiometer assembly (6) to the housing assembly, using two 3-48 x $\frac{3}{8}$ -inch fillister-head screws.

CAUTION

Use extreme care to avoid nicking or damaging the potentiometer windings in any way during installation.

(f) Attach rudder pick-up potentiometer assembly (9) to the housing assembly, using one 3-48 x $\frac{3}{8}$ -inch fillister-head screw in the upper right hole of the bracket. Do not tighten this screw, but move the resistor card assembly (8) into place and insert two 3-48 x $\frac{7}{8}$ -inch fillister-head screws through the eyelets of the resistor card. Place a short spacer under the left-hand screw, taking care that the screw passes through the hole in the potentiometer bracket, and a long spacer under the right-hand screw. Turn these screws into the housing and tighten all three screws which attach the potentiometer bracket and resistor card.

(3) ASSEMBLE AND INSTALL ROCKER ARM MOUNTING BLOCK ASSEMBLY. (See figure 307.)

(a) Slip the rocker arm assembly (15) over the stud on the rocker arm mounting block (4) and then slip the spacer over the stud and snap the snapping into place to secure them on the stud. Make sure that the rocker assembly turns freely on the stud.

(b) Install the centering spring stop (6) on the block, using two 3-48 x $\frac{1}{4}$ -inch fillister-head screws. Install the rocker arm stop bracket (3), using two 3-48 x $\frac{1}{4}$ -inch fillister-head screws.

(c) Install the rocker arm centering spring bracket assemblies (14 and 7), using four 3-48 x $\frac{1}{4}$ -inch fillister-head screws. Be sure that the slotted holes in these bracket assemblies fit over the eccentrics (8 and 13) on the block.

(d) Secure the erecting cut-out switch operating cams (11) to the cam mounting bracket (12), using two 3-48 x $\frac{3}{8}$ -inch binding head screws. Secure the erecting cut-out switch cam bracket assembly to the block with two 3-48 x $\frac{1}{4}$ -inch fillister-head screws. Keep this bracket as far toward the front of the block as possible so that it will not short against the slide or slide guides when the block is installed. Slip a spring lock washer over a 3-48 x $\frac{3}{8}$ -inch binding head screw

and use this screw to secure a two-inch flex lead (16) and a three-inch flex lead (17) to the block.

(e) Attach the two banking potentiometer wiper assemblies (9 and 10) to the block, using four 3-48 x $\frac{3}{16}$ -inch fillister-head screws with a plain washer under the lower left-hand screw and the upper right-hand screw, and two hole washers under each pair of screws attaching each wiper assembly.

(f) Attach the complete mounting block assembly to the slide in the housing assembly, using two 4-40 x $\frac{3}{8}$ -inch fillister-head screws. Touch one lead wire from a high voltage a-c source (110 volts or more) to the cam mounting bracket (12) and the other lead to the panel housing to test for possible short between bracket and slide guide. Move the slide from end to end while making this test.

(g) Place the rudder potentiometer wiper assembly (1) on the rocker assembly and secure it in place, using two 3-48 x $\frac{3}{16}$ -inch binding head screws through the wiper holding plate (2) and the wiper assembly. Place a plain washer under the right-hand screw and over the lug of the two-inch flex lead (16) attached to the block.

(h) Lift the retaining spring on the bell crank assembly and remove the link pin, insert the end of the connecting arm assembly (5), and replace the link pin securing it in place again with the spring.

(4) INSTALL AN RECEPTACLE.

(See figure 305.)

(a) Install the three-prong AN receptacle (10) in the left-hand hole at the bottom of the housing assembly, with locating key on side toward front of unit, using four 4-40 x $\frac{3}{16}$ -inch fillister-head screws.

(b) Install the seven-prong AN receptacle assembly (5) in the right-hand hole at the bottom of the housing assembly, using four 4-40 x $\frac{3}{16}$ -inch fillister-head screws.

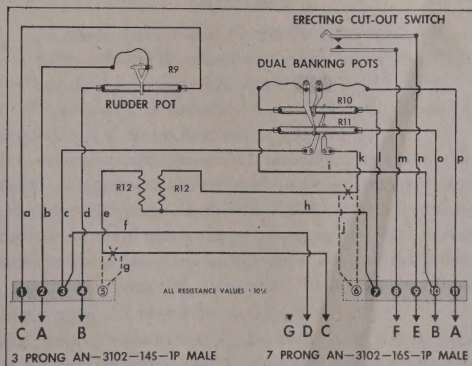


Figure 311 — Directional Panel Wiring Diagram

(5) INSTALL WIRING AND CHECK CONTINUITY. (See figure 311.)

(a) Consider the terminals on the two terminal blocks numbered one through eleven from left to right. Make the following connections:

Note

The first issue of directional panels had only four terminals on the left-hand terminal block and five terminals on the right-hand terminal block. In the second issue, the left-hand strip was changed to a five-terminal strip so that the lead ϵ could be conveniently opened for testing. The right-hand terminal block remained the same on this second issue of panels. On the third issue of directional panels, the left terminal strip remained the same and the right strip was changed to accommodate six terminals. In this instance, lead k was opened and lead j and k were both attached to terminal No. 6. It is, therefore, important to note specifically which wiring arrangement is used in the particular panel being overhauled so that tests may be made correctly. The wiring diagram (figure 311) will serve as a check guide for all three terminal arrangements provided in the G1005B directional panels.

1. Connect the $\frac{1}{4}$ -inch lead wire from pin C of the left-hand AN receptacle and the three-inch lead wire from the right-hand side of the rudder potentiometer to terminal No. 1.

2. Connect the $\frac{2}{4}$ -inch lead wire from terminal A of the left-hand AN receptacle and the 3-inch flex lead from the rocker arm mounting block to terminal No. 2.

3. Connect the 3-inch lead wire from prong D of the right-hand AN receptacle and the $\frac{3}{2}$ -inch lead wire from the left-hand center contact assembly of the dual banking potentiometer assembly to terminal No. 3.

4. Connect the $\frac{3}{4}$ -inch lead wire from prong B of the left-hand AN receptacle and the 3-inch lead wire from the left-hand end of the rudder potentiometer to terminal No. 4.

5. Connect the $\frac{2}{4}$ -inch lead wire from the left-hand side of the resistor card and the 2-inch lead wire from prong C of the right-hand AN receptacle to terminal No. 5.

Note

In the first issue of directional panels there is no terminal No. 5 and the connection is made directly between the left-hand side of the resistor card and prong C of the right-hand AN receptacle.

6. Connect the $3\frac{1}{2}$ -inch lead wire from the right-hand end of the resistor card assembly and the 2-inch lead wire from the right-hand center contact assembly on the dual banking potentiometer assembly to terminal No. 6.

Note

First and second issues of the directional panel had no terminal No. 6 and the connection was made directly from the right-hand end of the resistor card assembly to the right-hand center contact assembly on the dual banking potentiometer assembly.

7. Connect the $3\frac{1}{2}$ -inch lead wire from the center of the resistor card assembly and the $2\frac{1}{2}$ -inch lead wire from the right-hand end of the upper potentiometer in the dual banking potentiometer assembly to terminal No. 7.

8. Connect the 3-inch lead wire from prong F of the right-hand AN receptacle and the 3-inch lead wire from the lower contact strip of the erecting cut-out switch to terminal No. 8.

9. Connect the 3-inch lead wire from prong E of the right-hand AN receptacle and the 3-inch lead wire from the upper contact strip of the erecting cut-out switch to terminal No. 9.

10. Connect the $2\frac{3}{4}$ -inch lead wire from prong B of the right-hand AN receptacle and the lead wires from the left and right sides of the lower potentiometer in the dual banking potentiometer assembly to terminal No. 10. The lead wire from the left side of the potentiometer is $2\frac{1}{2}$ inches long and the lead wire from the right side is $1\frac{1}{2}$ inches long.

11. Connect the $3\frac{3}{4}$ -inch lead wire from prong A of the right-hand AN receptacle and the lower terminal lug of the covered $4\frac{1}{2}$ -inch flex lead which attaches to the wiper on the upper potentiometer of the dual banking potentiometer assembly to terminal No. 11.

12. Attach the upper terminal lug of the $4\frac{1}{2}$ -inch covered flex lead which was attached to terminal No. 11 to the wiper on the upper potentiometer of the dual banking potentiometer assembly. Make sure that the terminal lug falls between the plain washer and the upper $3\text{-}48 \times \frac{1}{16}$ -inch fillister-head screw. Attach the upper lug of the $5\frac{1}{2}$ -inch covered flex lead which attaches to the left-hand side of the upper potentiometer of the dual banking potentiometer assembly to the wiper blade which contacts the lower potentiometer, being sure that the terminal lug falls between the flat washer and the two-hole washer and is secured in place by the lower $3\text{-}48 \times \frac{1}{16}$ -inch fillister-head screw which attaches the wiper blade.

13. All connections to the terminal blocks are made with $3\text{-}48 \times \frac{1}{16}$ -inch binding head screws.

(b) Check continuity with an ohmmeter to be sure all connections are made in accordance with the wiring diagram (figure 311).

(6) FINAL ADJUSTMENTS.

(a) ADJUST WIPER TENSIONS.

1. Make a small wire hook for the end of the gram gage to facilitate checking wiper tensions.

2. Engage the hook of the gram gage around the end of the rudder potentiometer wiper, and then slowly move the gram gage and note the reading when the potentiometer wiper just breaks contact with the winding. (See figure 312.) This tension should be 6 to 8 grams.

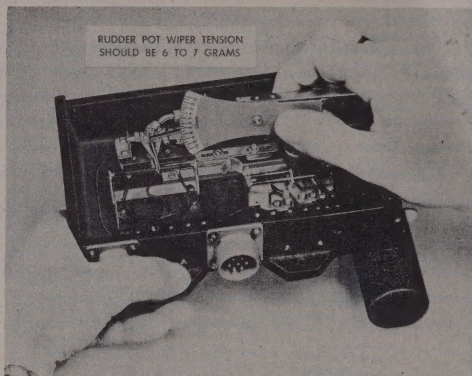


Figure 312 — Checking Rudder Potentiometer Wiper Tension

3. To decrease potentiometer wiper tension, lift the end of the wiper with the fingers to spring the blade slightly. (See figure 313.)

CAUTION

Be very careful not to distort the blade by bending the wiper too much. Bend the wiper only a little at a time and repeat the tension check until the correct tension is obtained.

4. To increase wiper tension, it is necessary to remove the wiper from the rocker arm assembly and slightly form the wiper blade with the fingers. When forming the wiper blade in this manner, it is advisable from a time standpoint, to give the blade a distinct form which will produce more than sufficient tension, and then decrease the tension as necessary.

5. Engage the hook of the gram gage under each of the dual banking potentiometer wipers and check the tension of each in the same manner as in checking the rudder potentiometer wiper. This tension should be 8 to 12 grams.

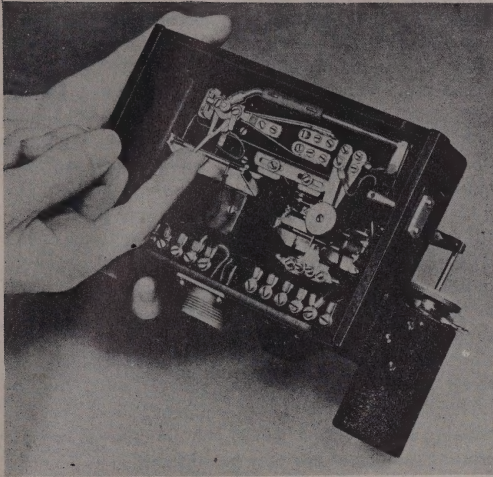


Figure 313 — Adjusting Rudder Potentiometer Wiper Tension

6. Increase or decrease the wiper tension as required.

(b) ADJUST TENSION OF CENTER CONTACT ASSEMBLIES.—Check the tension of the center contact assemblies against the potentiometers of the dual banking potentiometer assembly with a gram gage. This tension should be 25 grams minimum. Adjust the tension by bending the blades if necessary.

(c) ADJUST BANKING POTENTIOMETER CENTER CONTACT ASSEMBLIES. (See figure 314.)

1. Place a piece of paper (1) between the left-hand wiper (2) and the lower potentiometer winding (3).

2. Connect an ohmmeter between terminal No. 7 on the right-hand terminal block and the wiper which was just insulated from the lower potentiometer winding. Observe the total resistance of the upper potentiometer (4).

3. Connect the ohmmeter leads between terminal Nos. 3 and 7, and adjust the left-hand center contact assembly (5) which contacts the upper potentiometer winding until the ohmmeter reads half of the total resistance (tolerance .7%) observed in the preceding step. This is done by loosening the screws and shifting the contacts. Be sure to tighten the screws holding the contact in place as soon as the adjustment is made.

4. Remove leads from terminal No. 10 and connect the ohmmeter leads to the two lead wires attached to either end of the lower potentiometer wind-

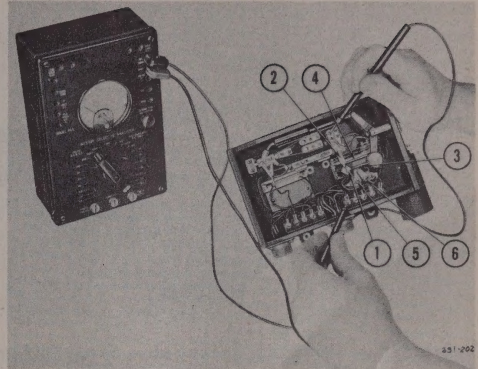


Figure 314 — Adjusting Banking Potentiometer Center Cutout Assemblies

Index No.	Nomenclature
1.	Paper
2.	Left-Hand Wiper
3.	Lower Potentiometer Winding
4.	Upper Potentiometer
5.	Left-Center Contact Assembly
6.	Right-Center Contact Assembly

ing. Read the total resistance of the lower winding (3).

5. Connect one ohmmeter lead to the lead wire from either end of the potentiometer winding and the ohmmeter leads to the right-hand center contact assembly (6) which contacts the lower potentiometer. Adjust this contact by loosening the screws and shifting it in the proper direction until the ohmmeter reads half of the total resistance of the potentiometer winding (tolerance .7%) noted in the preceding step. Be sure to tighten the screws holding the contact in place and replace the leads to terminal No. 10.

6. Remove the paper (1) from under the wiper which contacts the lower potentiometer winding.

(d) ADJUST ROCKER ARM.

1. (See figure 307.)—Slightly loosen the lock screws on the rocker arm centering spring bracket assemblies (7 and 14) and turn the eccentrics (8 and 13) to apply tension of 8 grams (plus or minus 1) on the spring stop (6).

2. Loosen the spring stop lock screws and adjust the stop so that the rocker arm (15) is held in a horizontal position. Retighten these screws.

3. Adjust the shape of the centering springs so that there is no more than .001 inch between the springs and the rocker (15) while the springs are resting against the spring stop (6).

4. Grasp these springs with the fingers so that the rocker arm cannot move and with a thickness gage,

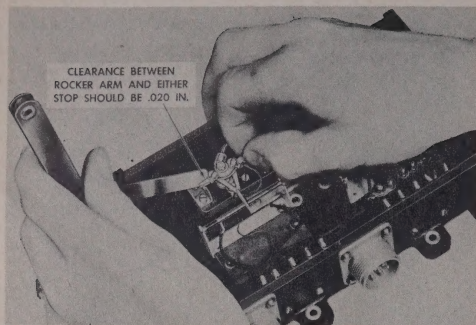


Figure 315 — Checking Rocker Arm Stop Setting

measure the clearance between the end of the rocker arm and the rocker arm stop. (See figure 315.) The rocker arm should be centered between stops (tolerance .002 inch). Adjust the rocker arm stop to give this clearance by loosening the screws and moving the stop to the correct position and bending the lugs so that the required clearance is obtained.

5. Measure the tension of the centering springs with a gram gage. (See figure 316.) This tension should be 7 to 9 grams. Adjust this tension to the correct value by slightly loosening the left-hand screw which secures each centering spring bracket assembly to the mounting block and rotating the eccentric adjusting screw. When the proper tension is obtained, retighten these mounting screws and again check to make sure that this adjustment is correct.

(e) Install the directional panel on a test fixture or on a stabilizer with the four mounting screws provided, being careful to see that the rounded end of the

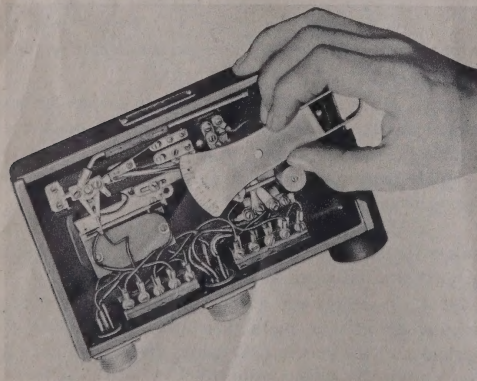


Figure 316 — Checking Rocker Arm Centering Spring Tension

directional drive arm assembly enters the hole in the slide.

(f) Check the stabilizer to see that the pilot's directional indicator wiper moves five and a quarter degrees on each side of center as the autopilot clutch arm is moved from one stop to the other. Then set the pilot's directional indicator wiper at zero by moving the autopilot clutch arm to its center position. Depress the directional arm lock plunger and place a pencil point between the operating lever and the lower clamping jaw to hold the autopilot clutch in a fixed position. (See figure 317.) Loosen the locking screw on the directional drive arm and rotate the eccentric so that the locking screw is in the exact center of the slot through which it passes. Tighten the locking screw. The directional panel slide is now properly centered and the rudder potentiometer and the two banking potentiometer wipers may be centered and the erecting cut-out switch may be adjusted.

(g) ADJUST RUDDER POTENTIOMETER WIPER.

1. Connect the ohmmeter leads between terminal Nos. 1 and 4. (See figure 311.) Note the exact total resistance of the potentiometer winding.

2. Connect the ohmmeter leads between terminal Nos. 1 and 2 and check the resistance between these two terminals. This resistance should be one-half of the total resistance of the potentiometer winding (tolerance .7%).

3. If the adjustment is not correct, loosen the two screws holding the wiper to the rocker arm assembly. Then grasp the centering springs at the end of the rocker arm to keep the rocker arm assemblies from tilting and carefully move the end of the wiper

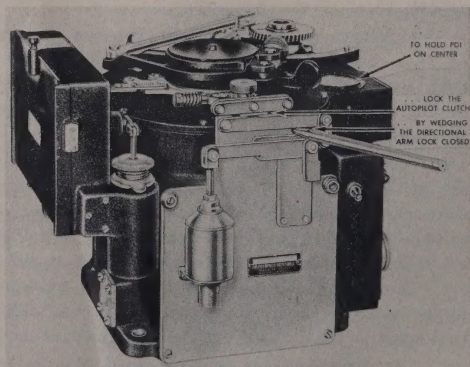


Figure 317 — Wedging Arm Lock to Autopilot Clutch Arm in Position

until the ohmmeter reads one-half of the resistance of the entire potentiometer winding. When this adjustment is made, tighten the two screws holding the wiper to the rocker arm assembly and recheck to make sure that the adjustment is correct. In retightening these screws, make sure that the flex leads to the wiper do not interfere with the movement of the wiper and do not touch other parts or each other.

(b) ADJUST BANKING
POTENTIOMETER WIPERS.

1. Connect the ohmmeter leads to the left-hand wiper, which contacts the lower potentiometer winding, and to the right-hand center contact assembly which also contacts this winding.

2. Loosen the two screws which hold this wiper in place and adjust the wiper so that the ohmmeter reads as close to 0 as possible. In this position the wiper should be exactly opposite the center contact assembly.

3. Connect the ohmmeter between the right-hand wiper, which contacts the upper potentiometer winding, and the left-hand center contact assembly, which also contacts this winding. Loosen the two screws which hold this wiper in place and adjust the wiper until the ohmmeter reads as close to 0 as possible. In this position, the wiper will be exactly opposite the center contact assembly.

4. Carefully tighten the screws which secure the wipers in place and again check to see that the adjustment has not changed.

(i) ADJUST THE ERECTING CUT-
OUT SWITCH BLADES AND CAM.

1. Measure the clearance between the upper switch blade cam surface and the cam holding bracket. This clearance should be .020 inch maximum. Bend the upper blade slightly near its point of support with a pair of long-nosed pliers to provide the correct clearance at this point.

2. With the switch contacts closed, check the tension of the lower blade with a gram gage. This tension should not be less than 10 grams. Adjust the tension, if necessary, by slightly bending the lower blade near its point of support by means of a long-nosed pliers.

3. Remove the pencil from the directional arm lock which locks the autopilot clutch arm in position and move the autopilot clutch until the pilot directional indicator wiper indicates $1\frac{1}{2}$ degrees to one side of the 0 degree setting (.080-inch movement of the slide equals 1°). Replace the pencil to lock the autopilot clutch in this position.

4. Adjust the position of the cam which is now closest to the V-shaped hump on the upper blade of the switch so that it depresses the upper blade to

just make contact at this point. Tighten the binding-head screw to lock the cam in this position.

5. Remove the pencil from the directional arm lock and move the autopilot clutch arm so that the pilot directional indicator wiper moves to the $1\frac{1}{2}$ degree position on the other side of the 0 setting, and lock it in this position by replacing the pencil in the directional arm lock.

6. Loosen the locking screw holding the cam which is now closest to the V-shaped hump on the upper blade of the switch and move this cam until contact between the switch contact point is just made. Tighten the binding-head locking screw to lock the clamp in this position.

7. Check the clearance between the upper and lower contacts when the switch is fully opened. This clearance should be $1/64$ to $3/64$ inch. If this clearance is incorrect, bend the lower blade near its point of support by means of a long-nosed pliers to give the proper adjustment, and recheck tension.

(j) FORM FLEX LEADS.—Using two pair of tweezers, form the flex leads so that they do not interfere in any way with the free operation of the unit, and that they do not touch any parts or themselves throughout the entire range of movement.

(k) CHECK FREEDOM OF
MOVEMENT OF RUDDER
POTENTIOMETER WIPER.

1. Remove the directional panel from the stabilizer and lay it face up on the bench.

2. Place the eraser end of a pencil between the centering springs as shown in figure 318. Then place the end of a gram gage against the end of the rudder potentiometer wiper and move it to one side. Note the gram gage reading at the point where the rudder potentiometer wiper just begins to move.

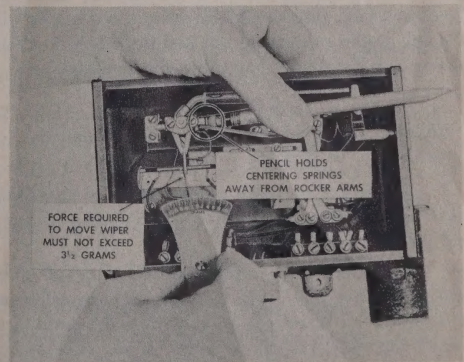


Figure 318 — Checking Freedom of Rudder Potentiometer Wiper Movement

3. This value must be less than $3\frac{1}{2}$ grams. If this reading is more than this amount when the wiper tension is properly adjusted (6 to 8 grams tension), there is binding in the linkage connecting the slide to the dash pot.

4. If too high a reading is obtained, it is necessary to polish the connecting rod pins or the rocker arm shaft or to realign the yoke and rod assembly with the bell crank connection.

(1) CHECK POTENTIOMETERS FOR CLEANLINESS AND SHORTED TURNS.—Check the potentiometers for cleanliness, using an ohmmeter connected from one end of the potentiometer to the potentiometer wiper. Move the wiper very slowly across the potentiometer windings. Any flicker of the ohmmeter needle indicates dirt on the winding, and any hesitation of the needle, will indicate shorted turns in the potentiometer. Clean the potentiometer, if necessary, with a clean cotton cloth slightly wet with alcohol and remove residue with lint free cloth.

(7) ASSEMBLE AND INSTALL DASH
POT ASSEMBLY. (See figure 306.)

(a) Screw the cylinder locking nut (3) onto the cylinder assembly (2).

(b) Insert the piston assembly (1) into the cylinder assembly and press the anti-splash cover tightly into the cylinder.

(c) Screw the cylinder assembly all the way into the housing assembly so that it is in its position of maximum resistance to piston travel. Hold the housing assembly in a vertical position and raise the piston up as far as it will go. Release the piston and check the length of time required for the piston to fall to the bottom of its stroke. This should require not less than 10 seconds, with no oil in the assembly and with all surfaces dry and clean. If less than this time is required, the piston is not seating properly in the cylinder, or the cylinder is not seating properly in the housing and the faulty parts must be replaced.

CAUTION

Avoid interchanging parts. If absolutely necessary, be sure the parts fit properly.

(d) Secure the dash pot assembly to the directional panel housing using three 4-40 x $\frac{7}{8}$ -inch fillister-head screws.

(e) Make final check for freedom of slide movement. (See figure 319.) Set the directional panel on its lower left-hand corner and press the crank arm toward the dash pot to raise the slide. Release the crank arm and see that the slide falls freely to the low end of the panel. If the slide tends to stick, the unit must be disassembled and the slide guides adjusted to



Figure 319 — Checking Freedom of Directional Panel Slide Movement

give more freedom of movement. This binding may be removed by stoning down the slide with a fine India stone or shimming the slide guides to give the proper clearance. A clearance of .002 to .005 must be provided.

(f) Lift the retaining spring and turn it aside to remove the connecting rod link pin which connects the dash pot piston rod assembly to the dash pot actuating lever assembly. Reinsert this pin through the piston rod and lever and secure it in place again with the retaining spring.

(8) ASSEMBLE AND INSTALL COVER. (See figure 305.)—Secure the knob to the cover with two 3-48 x $\frac{3}{8}$ -inch flathead screws. Insert cover in slot in housing.

5. DIRECTIONAL ARM LOCK ASSEMBLY.

a. GENERAL.

(1) The directional arm lock assembly mounts on the side of the directional stabilizer to provide a means of locking the autopilot clutch assembly in its center position.

(2) The directional arm lock is considered as a separate assembly since it is readily detached from the stabilizer and the only mechanical connection with the stabilizer is provided by the mounting screws.

b. OVERHAUL TOOLS REQUIRED.—No special overhaul tools are required to overhaul the directional arm lock assembly.

c. DISASSEMBLY.

**(1) REMOVE AND DISASSEMBLE
ACTUATING SOLENOID AS-
SEMBLY. (See figure 320.)**

(a) Remove the two screws and lock washers which extend through the solenoid cover (8) to attach the assembly to the arm lock base (2), and slide the solenoid assembly from the plunger (4).

makes contact with the lock strip. Place a plain washer (9, figure 321) (.147 inch inside diameter x .375 inch outside diameter x .064 inch thickness) over each end of the link pin and pin over the ends of the link pin. Be sure that there is freedom of movement in this connection.

(c) Slip the actuating lever (6) between the two links (4) and insert the second link pin (8) through the two links and through the short end of the actuating lever. Place a plain washer (9) (.147 inch inside diameter x .375 inch outside diameter x .064 inch thickness) on each end of the link pin and pin over the ends of the pin carefully. Be sure that there is freedom of motion at this connection.

(d) Attach the linkage mounting bracket (13) to the base (1) using four tubular rivets (12). Three of these rivets are inserted from the front and enter the bracket first and the fourth is inserted from the rear to provide easy access to this rivet for riveting it into place.

(e) Slip the assembled arm links and lever into place under the linkage mounting bracket and insert the actuating lever pin (10) through the bracket, the lever, and the base, being sure to insert the return spring (7) between the two arms of the lever. Place a plain washer (11) (.147 inch inside diameter x .375 inch outside diameter x .064 inch thickness) on each end of the actuating lever pin and pin over the ends of the pin to secure it in place.

(f) Insert the clamp arm bearing pin (17) into the end of the clamp arm and through the base and rivet it in place.

(g) With a pair of long-nosed pliers, bend the return spring (7) around so that one arm of the spring will rest against the lever and the other arm against the inside of the bracket to hold the assembly in a released position.

(b) Insert the clevice pin (15) in the plunger clevice (16) and the actuating lever and place a plain washer (14) (.147 inch inside diameter x .375 inch outside diameter x .064 inch thickness) over each end of this pin. Pin over the ends of the pin to secure it in place. Screw the hex locknut onto the plunger clevice.

(2) ASSEMBLE AND INSTALL ACTUATING SOLENOID ASSEMBLY. (See figure 320.)

(a) Slide the receptacle end insulator over the lead wire on the actuating solenoid coil assembly (5) and insert the receptacle pin through the receptacle pin insulator.

(b) Solder the lead wire end to the inner end of the receptacle pin and place a little shellac on the end of the coil assembly so that the receptacle end insulator will adhere to the assembly and press the insulator into the counterbore. Slip the flat insulating washer over the receptacle pin insulator.

(c) Slide the solenoid shell (7) over the coil assembly (5) and install the solenoid cover (8) using four 4-40 x 1/4-inch fillister-head screws with medium spring lock washers.

(d) Screw the plunger (4) onto the plunger clevice and slip the actuating solenoid assembly over the plunger. Secure the solenoid assembly to the base using two 6-32 x 1/4-inch fillister-head screws and medium spring lock washers.

(3) CHECK ADJUSTMENT OF SOLENOID PLUNGER.

(a) Insert an autopilot clutch arm extension between the clamping jaws and apply just enough clutch pressure to the plunger clevice to close the clamping jaws.

(b) Mark a pencil line on the plunger at the top of the solenoid.

(c) Force the plunger to the bottom of the solenoid and make another mark on the plunger.

(d) The two marks made on the plunger must be between 3/32-inch to 1/8-inch apart. Adjust the solenoid plunger on the plunger clevice until this adjustment is obtained, and turn the lock nut down tight against the plunger.

6. SERVO UNIT.

a. GENERAL.

(1) The three servo units which operate the control surfaces of the airplane are identical and therefore overhaul instructions for only one unit are given.

(2) Since the servo units actually operate and connect directly to the control surfaces of the airplane, failure of the servo units may cause disaster during flight. Therefore, *more than ordinary care must be exercised in the overhaul of these units.*

b. OVERHAUL TOOLS REQUIRED.

(1) The following special tools should be available for use in disassembly, inspection, repair and reassembly of the servo unit, in addition to an assortment of standard tools, such as screw drivers, pliers, wrenches, etc.

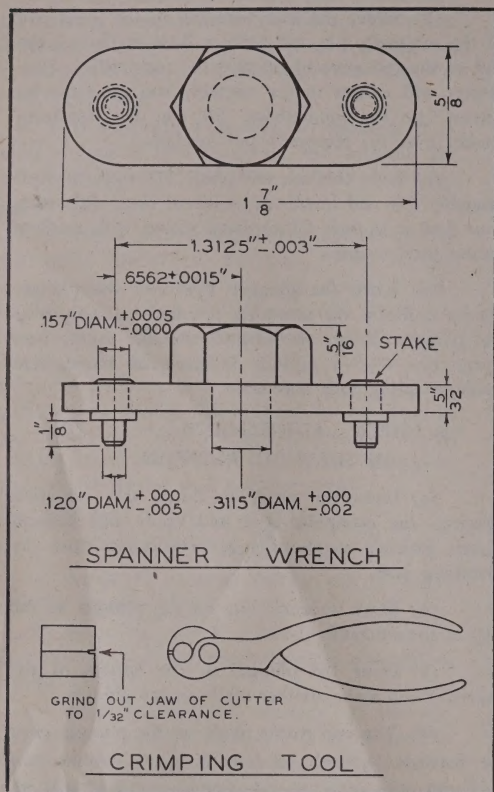


Figure 322 — Special Tools, Servo Unit

(2) SPECIAL TOOLS. (See figure 322.)

Nomenclature	Application
Spanner Wrench	To remove and install solenoid housing covers
0-150 Gram Gage	For checking contact tension
0-50 Gram Gage	For testing wiper tension
0-8 Ounce Spring Scale	For testing brush tension
Crimping Tool	For crimping ends of brake arm pins
Thickness Gage	For testing end play
Spray Scale Test Fixture	For making final adjustments
Servo Motor Test Set	For making final adjustments

c. DISASSEMBLY.

Note

The clutch and differential housing assembly of the servo unit forms the central structure to which all other parts are mounted. Disassembly of parts mounted on either side of this clutch and differential housing assembly may be carried out separately without disturbing parts on the other side, once the first 3 steps of the disassembly procedure outlined below have been performed. If only the electrical parts on the back of the unit (operating solenoids, brake solenoids, and motor) need attention, these may be disassembled by following the disassembly procedure through step 8. If only parts on the front side of the differential housing assembly need attention (potentiometer, cable drum, clutch assemblies, and brake assemblies) the first three steps should be performed, and also steps 9 through 13.

The front end of the servo unit is considered as the cable drum end; and all reference to left-hand or right-hand parts, whether mounted in front or behind the clutch and differential housing assembly, are to parts located on the left or right, when viewing the unit from the cable drum end.

(1) REMOVE EXTERIOR COVER ASSEMBLY. (See figure 323.)—Remove the thin hex nut (1) and large internal tooth lock washer (2) which secure the servo unit exterior cover assembly (3) to the unit. Remove the cover assembly.

(2) REMOVE AND DISASSEMBLE SERVO UNIT BASE ASSEMBLY. (See figure 323.)

(a) Remove the three binding-head screws securing the lead wires from the AN receptacle to the balance potentiometer terminal block; the three binding-head screws securing leads from the AN receptacle to the limit switch mounting base assembly; and the one binding-head screw securing the motor lead from the AN receptacle to the brush holder cap on the motor brush assembly.

(b) Remove the four fillister-head screws (5) which secure the base assembly (4) to the clutch and differential housing assembly, and the two fillister-head screws (9) which secure it to the end plate assembly. Remove the base assembly.

(c) Remove the AN receptacle cover (7) from the adapter (6) by removing the four fillister-head screws with internal tooth lock washers securing it to the adapter.

(d) Remove the AN receptacle (8) from the adapter by removing the four fillister-head screws and washers securing it to the adapter.

(e) Remove the four fillister-head screws with lock washers securing the AN receptacle adapter (6) to the base assembly (4).

(f) It is not necessary to remove the six fillister-head screws which hold the three electric outlet auxiliary covers to the base assembly unless it is desired to change the location of the AN receptacle.

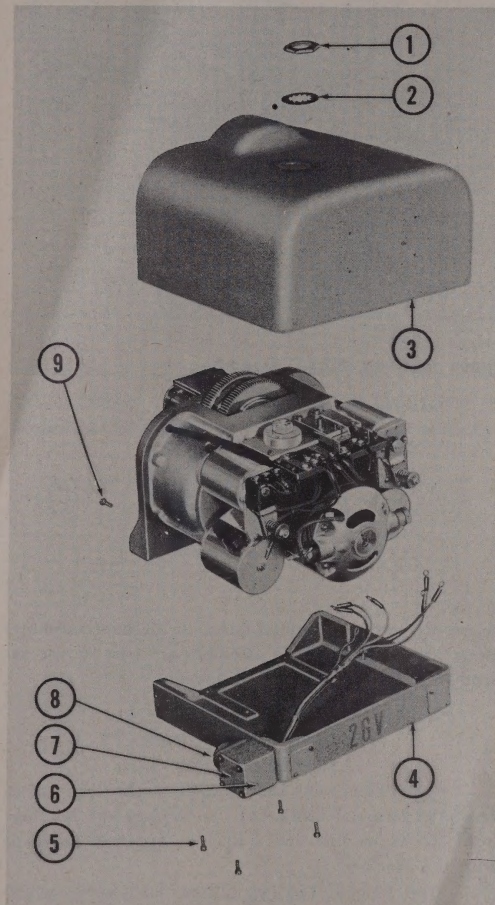


Figure 323 — Exploded View of Cover and Base Assemblies

Index No.	Nomenclature
1.	Hex Nut
2.	Lock Washer
3.	Cover Assembly
4.	Base Assembly
5.	Screws
6.	Adapter
7.	AN Receptacle Cover
8.	AN Receptacle
9.	Screws

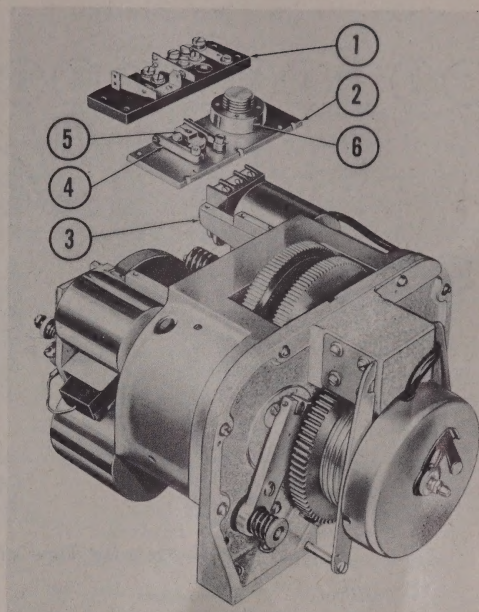


Figure 324 — Limit Switch Mounting Base and Limit Cam Shaft Base

Index No.	Nomenclature
1.	Limit Switch Mounting Base
2.	Cam Shaft Base Assembly
3.	Terminal Block Bracket
4.	Levers
5.	Limit Cam
6.	Cover Retaining Collar

(3) REMOVE AND DISASSEMBLE
LIMIT CAM SHAFT BASE
ASSEMBLY. (See figure 324.)

(a) Remove the four fillister-head screws which secure the limit cam shaft base assembly (2) to the limit cam shaft base and terminal block bracket (3). Remove the base assembly.

(b) Loosen the clamping screw which clamps the limit cam (5) to the limit cam and gear shaft; remove the limit switch cam assembly.

(c) Using a small drift pin to loosen the taper pin securing the limit cam shaft gear to the shaft, remove the taper pin, shaft, and gear.

(d) Loosen the two taper pins securing the limit switch lever retaining collars to the studs; remove the pins, collars, and levers (4).

(e) Remove the four fillister-head screws which secure the cover retaining collar (6) to the base; remove the cover retaining collar.

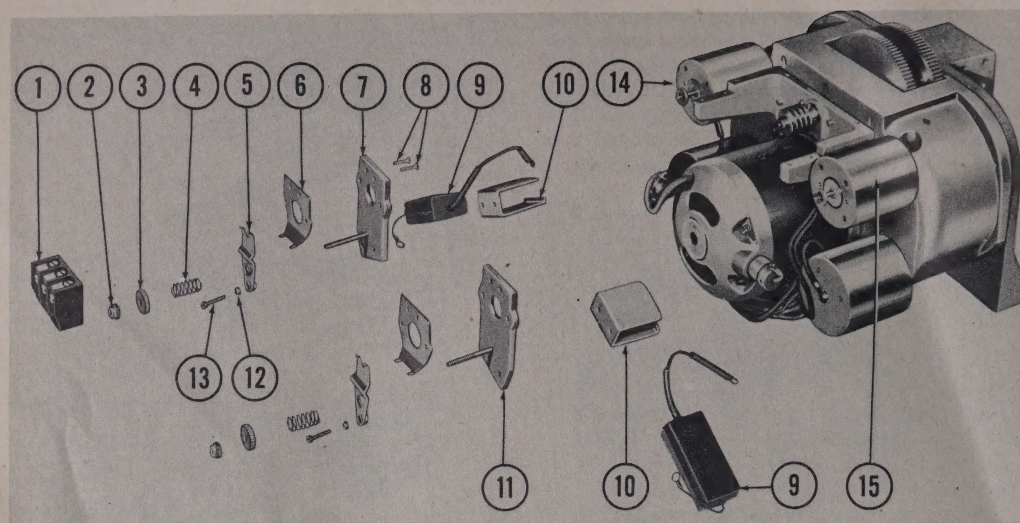


Figure 325 — Exploded View of Solenoid Back-up Plate Assemblies

Index No.	Nomenclature
1.	Terminal Block
2.	Lock Nut
3.	Spring Adjusting Nut
4.	Back-up Spring
5.	Rocker Arm Assembly
6.	Fulcrum Plate
7.	Back-up Plate
8.	Screws

Index No.	Nomenclature
9.	Condenser
10.	Condenser Mounting Plate
11.	Back-up Plate
12.	Hex Nuts
13.	Screws
14.	Right Hand Solenoid
15.	Left Hand Solenoid

(f) Do not attempt to remove any of the pins or studs or bushings which are pressed into the base to form the base assembly. Limit switch lever buttons must not be removed from the levers.

(4) REMOVE AND DISASSEMBLE
LIMIT SWITCH MOUNTING
BASE ASSEMBLY. (See figure 324.)

(a) Remove the binding-head screws and washers which secure all wires to the limit switch mounting base assembly (1). Remove the wires from the terminals. Binding-head screws should be replaced in the terminal block, since some of the terminal strips on the base assembly may otherwise come loose.

(b) Remove the four fillister-head screws attaching the limit switch mounting base assembly (1) to the limit cam shaft base and terminal block bracket (3). Remove the base assembly.

(c) The limit switch mounting base assembly may be disassembled by removing the two binding-head screws which secure the left- and right-hand limit switch contact blade assemblies to the base assembly and by removing the other binding-head screws which

secure the various terminal strips to the base assembly. Parts riveted to the base assembly are part of the assembly and should not be removed.

(5) REMOVE AND DISASSEMBLE
SOLENOID BACK-UP PLATE
ASSEMBLIES. (See figure 325.)

(a) Disconnect the potentiometer lead wires from the terminal block (1), but replace the binding-head screws so that the L-shaped terminals are kept with the block.

(b) Remove the two fillister-head screws which extend through the balance potentiometer terminal block (1) and secure the right-hand operating solenoid plunger back-up plate assembly to the cover of the operating solenoid housing (14) and the two fillister-head screws attaching the left-hand assembly. Remove the back-up plate assemblies.

Note

On late model Servo Units the balance potentiometer terminal block is not mounted on the right-hand operating solenoid plunger back-up plate assembly, but is secured to a

bracket on the limit switch mounting base assembly. All connections to this terminal block, however, are made in the same manner as to the original type block.

(c) Remove the two flathead screws (8) which attach the balance potentiometer terminal block assembly (1) to the right-hand back-up plate subassembly (7).

(d) Remove the rocker arm fulcrum plates (6). Remove the self-locking nuts (2) and the back-up spring adjusting nuts (3) from the back-up spring studs. Then, remove the back-up springs (4) and the plunger rocker arm assemblies (5). The fillister-head screws (13) and machine screw hex nuts (12) may be removed from the rocker arm assemblies, if desired.

(e) Remove the two fillister-head screws which attach each spark suppressing condenser mounting plate (10) to each back-up plate (7 and 11); remove the mounting plates and condensers. On Servo Units having molded condensers, the condensers (9) may be slipped out of the clamps for replacement, if necessary.

(6) REMOVE THE LEFT- AND RIGHT-HAND OPERATING SOLENOID HOUSING ASSEMBLIES. (See figure 326.)

(a) Remove the operating solenoid plunger assemblies (3, 4, and 5) from the solenoid housing if they were not pulled out when the operating solenoid plunger back-up plate assemblies were removed. The snap ring (3) on the end of the stud of each plunger (5) and the washer (4) may be removed, if necessary.

(b) Remove the operating solenoid push rods (9).

(c) Use the spanner wrench assembly (as shown in figure 327) to unscrew the operating solenoid covers (1 and 11, figure 326) from the left-hand solenoid housing (2) and the right-hand solenoid (10).

CAUTION

The right-hand solenoid housing and cover (1 and 2) and the left-hand solenoid housing and cover (10 and 11) are matched units and very carefully fitted together. If

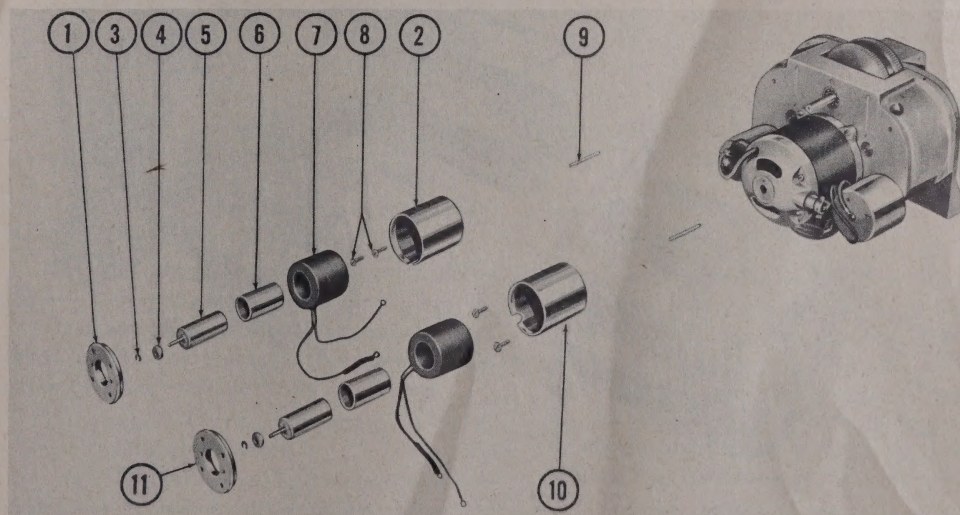
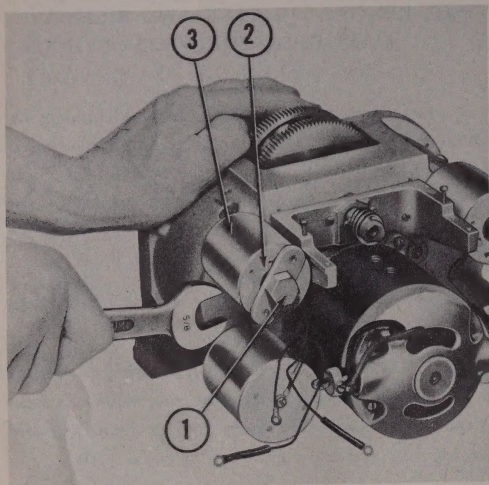


Figure 326 — Exploded View of Operating Solenoids

Index No.	Nomenclature	Index No.	Nomenclature
1.	Solenoid Cover	7.	Solenoid Winding
2.	Left-Hand Solenoid Housing	8.	Screws
3.	Snap Ring	9.	Push Rods
4.	Washer	10.	Right-Hand Solenoid Housing
5.	Plunger	11.	Solenoid Cover
6.	Guide Sleeve		

Figure 327 — Using Spanner Wrench on Operating Solenoid Covers



Index No.	Nomenclature
1.	Spanner Wrench
2.	Solenoid Cover
3.	Solenoid Housing

either is damaged, both parts must be replaced. Scribe the left-hand housing (10) and the left-hand cover (11) with an "L" and the right-hand housing (2) and the right-hand housing cover (1) with an "R", so that these parts cannot get mixed up and may be properly reinstalled. The left-hand cover may be stamped with an "R" and the right-hand cover with an "L". Do not let this be confusing.

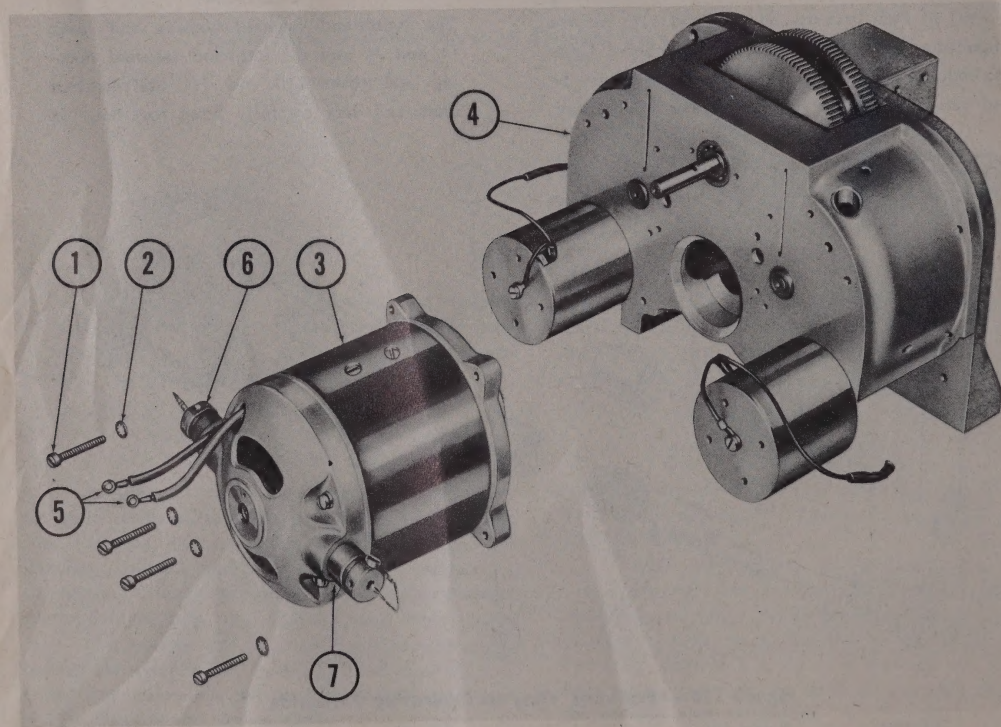


Figure 328 — Motor Assembly Removed

Index No.	Nomenclature
1.	Screws
2.	Lock Washers
3.	Motor Assembly
4.	Differential Housing Assembly

Index No.	Nomenclature
5.	Lead Wires
6.	Insulated Brush Holder
7.	Uninsulated Brush Holder

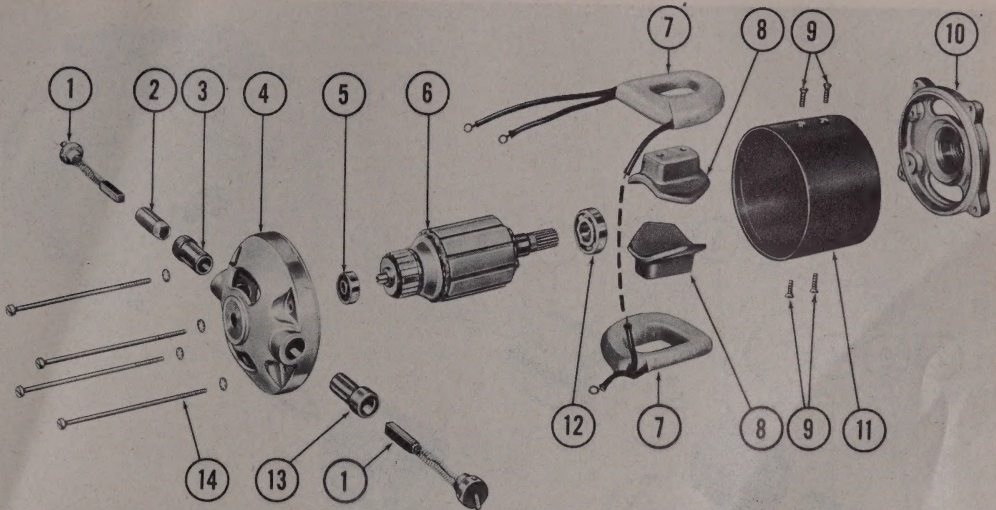


Figure 329 — Exploded View of Motor Assembly

Index No.	Nomenclature	Index No.	Nomenclature
1.	Brush Assembly	8.	Pole Piece
2.	Insulated Brush Holder	9.	Screws
3.	Insulating Sleeve	10.	Pinion End Frame
4.	Commutator End Frame Assembly	11.	Field Ring Assembly
5.	Bearing	12.	Bearing
6.	Armature Assembly	13.	Uninsulated Brush Holder
7.	Field Coils	14.	Through Bolts

(d) Slide the operating solenoid windings (7) out of the solenoid housings.

(e) Pull the solenoid plunger guide sleeves (6) out of the solenoid housings.

(f) Remove the two flathead screws (8) which attach each solenoid housing to the clutch and differential housing assembly; remove the housings.

(7) REMOVE AND DISASSEMBLE MOTOR ASSEMBLY.

(a) (See figure 328.)—Remove the four fillister-head screws (1) and internal tooth lock washers (2) which secure the motor assembly (3) to the clutch and differential housing assembly (4). Remove the motor assembly.

(b) Remove the binding-head screw which secures the motor field coil leads (5) to the insulated brush holder assembly (6); remove these leads from this terminal. Remove the roundhead screws which

connect the brush lead wires to the brush holder caps.

(c) Unscrew the brush holder caps. As the brush assembly is being removed from the insulated brush holder assembly (6), place a single scribe mark on the top of the insulating tube and on the top of the carbon brush as it is removed. As the brush assembly is removed from the uninsulated brush holder (7), place two scribe marks on top of the brush holder, and two scribe marks on top of the carbon brush to locate the brush assemblies for reassembly.

(d) (See figure 329.)—Remove the four motor through bolts (14) which hold the pinion end frame (10) and the commutator end frame assembly (4) together; with a soft hammer, tap these frames loose from the field ring assembly (11). (In some motors the end frames are held to the field assembly by eight screws.) Remove the round-head screw which attaches the grounded end of the field coils (7) to the com-

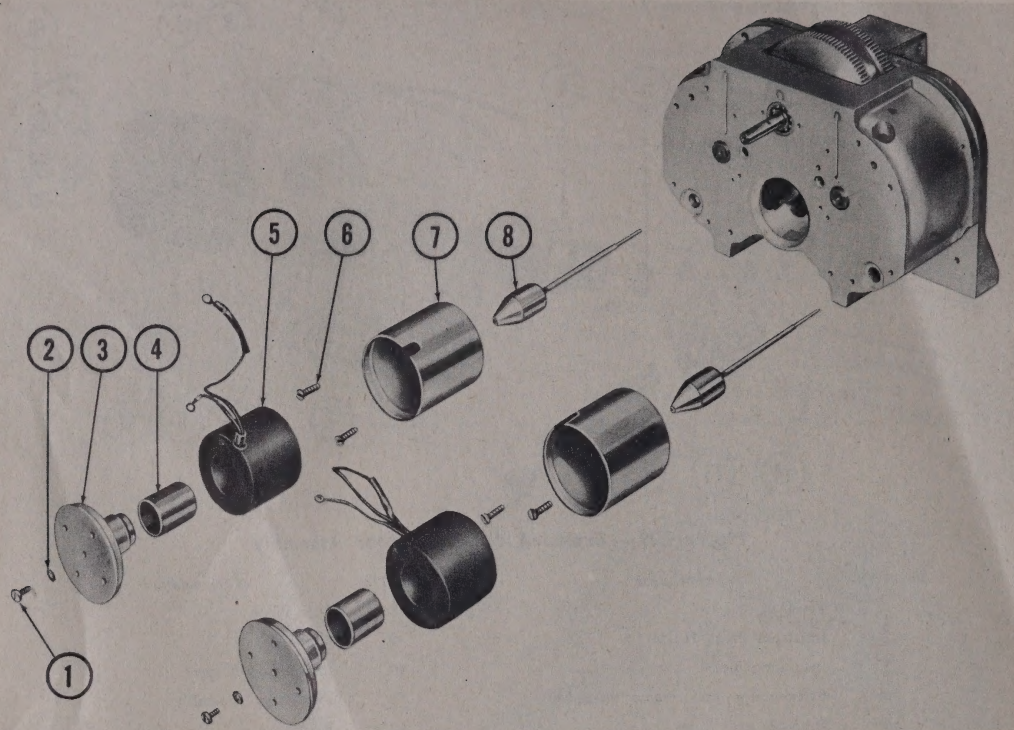


Figure 330 — Exploded View of Brake Solenoid Assemblies

Index No.	Nomenclature
1.	Screw
2.	Washer
3.	Solenoid Housing Cover
4.	Plunger Guide Sleeve

Index No.	Nomenclature
5.	Solenoid Winding
6.	Screws
7.	Solenoid Housing
8.	Solenoid Plunger

mutator end frame assembly (4). Remove the two frames and armature from the field ring assembly. Be careful not to lose any shims found under the motor bearing on the commutator end.

(e) If the bearings (5 and 12) cannot be pulled off the armature shaft, it may be necessary to press them off in an arbor press. If force must be used, however, the bearings will probably be damaged and should be discarded. If the bearings are removed without force and are not damaged, they should be placed in covered containers, properly marked.

(f) The noninsulated brush holder (13) is simply pressed into the commutator-end frame (4) while the insulated brush holder assembly (2 and 3) is held in place with two headless setscrews. Remove the insulated brush holder assembly by removing the

two headless setscrews and pressing it out of the frame. Then press the noninsulated brush holder out of the frame. (In some motors, headless set screws are used to hold both brush holders.)

(g) Remove the two flathead screws (9) which attach each pole piece (8) to the field ring assembly (11). These flathead screws are staked in place, and it will be necessary to loosen them before they can be removed. When the screws are removed, the pole pieces and the field coils (7) may be removed and separated.

(8) REMOVE THE BRAKE SOLENOID HOUSING AND PLUNGER ASSEMBLIES.

(a) (See figure 330.)—Remove the binding-head screws (1) and washers (2) which attach the

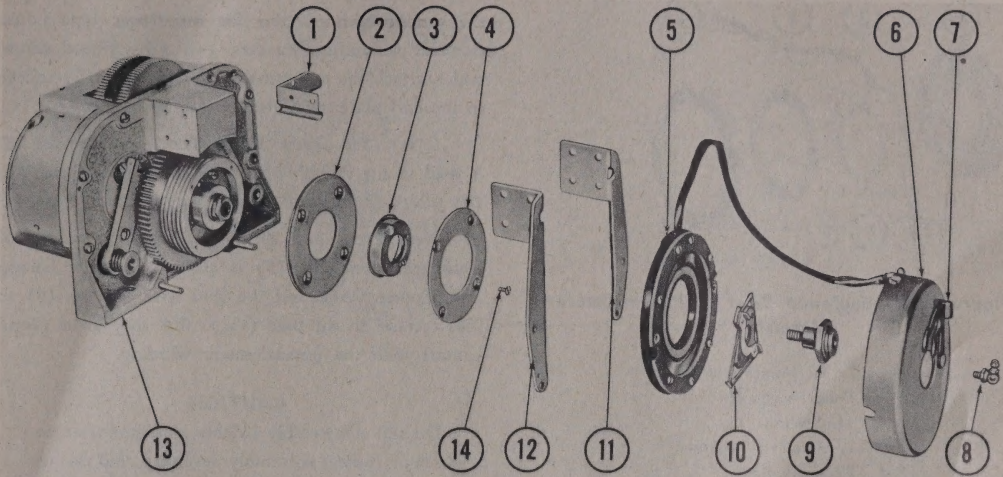


Figure 331 — Balance Potentiometer and Cover Assembly

Index No.	Nomenclature	Index No.	Nomenclature
1.	Balance Potentiometer Lead Wire Guard	8.	Grease Fitting
2.	Clutch Mounting Plate	9.	Grease Fitting Extension
3.	Clutch Friction Collar	10.	Potentiometer Wiper Assembly
4.	Clamping Washer	11.	Potentiometer Mounting Bracket
5.	Balance Potentiometer Assembly	12.	Potentiometer Mounting Bracket
6.	Potentiometer Cover Assembly	13.	Differential End Plate
7.	Potentiometer Cover Latch	14.	Screws

ground leads from the brake solenoid windings (5) to the brake solenoid housing covers (3).

(b) Using the spanner wrench assembly, unscrew the two brake solenoid housing cover assemblies (3) from the brake solenoid housings (7).

(c) Slide out the brake solenoid plunger assemblies (8).

Note

(See figure 336.)—The pull rods on these brake plunger assemblies are held to the brake arms (7) by the lock nuts (10) and adjusting nuts (11), which must first be removed. Remove the brake pull rod plain stop collar (14) and the bevel collar (13), which are located on the pull rods under the brake arms. These collars are carefully fitted for this particular servo unit and should be marked in removal, or placed in a marked

container, so that they may be replaced in exactly the same position.

(d) (See figure 330.)—Remove the two brake solenoid windings (5) from the housings (7).

(e) Pull out the brake plunger guide sleeves (4) from each housing.

(f) Remove the two flathead screws (6) which attach each brake solenoid housing (7) to the clutch and differential housing assembly. Remove the housings.

(9) REMOVE AND DISASSEMBLE POTENTIOMETER ASSEMBLY.

(a) (See figure 331.)—Lift the potentiometer cover latch (7), and remove the servo unit potentiometer cover assembly (6). This latch is riveted to the cover and should not be removed unless it is damaged and requires replacement.

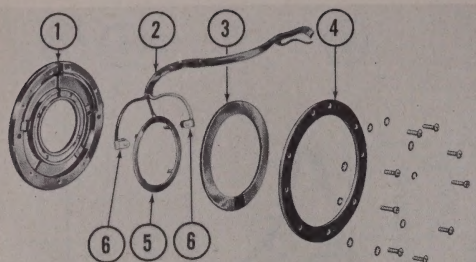


Figure 332 — Exploded View of Potentiometer Assembly

Index No.	Nomenclature
1.	Potentiometer Base
2.	Lead Wires
3.	Potentiometer Winding
4.	Retaining Ring
5.	Collector Ring Assembly
6.	Lead Wire Contacts

(b) Unscrew the pressure grease fitting (8) from the end of the grease fitting extension (9). Unscrew the grease fitting extension from the end of the cable drum shaft.

(c) Remove the two roundhead screws and lock washers holding the balance potentiometer wiper assembly (10) to the balance potentiometer assembly (5). Remove the wiper assembly.

(d) Remove the balance potentiometer lead wire guard (1) by removing the three fillister-head screws securing the lead wire guard and the right-hand potentiometer bracket (11) to the differential housing end plate assembly (13).

(e) Remove the remaining six drilled fillister-head screws attaching the potentiometer mounting brackets (11 and 12) to the differential housing end plate assembly (13).

(f) Remove the three binding-head screws which secure the potentiometer lead wires to the balance potentiometer terminal block (if not already disconnected at this point). Remove the balance potentiometer and bracket assembly by pulling the lead wires out through the plate assembly.

(g) Remove the two fillister-head screws which attach the potentiometer assembly (5) to the poten-

tiometer mounting brackets (11) and (12). Remove the mounting brackets. For the newer type potentiometer mounting brackets, two fillister-head screws which attach the mounting bracket to the two standoffs in the end plate must also be removed.

(h) (See figure 332.)—The potentiometer (3) is held in the assembly by an insulating retaining ring (4) which is fastened to the potentiometer base (1) by seven screws and spring lock washers. The collector ring assembly (5) is clipped into the balance potentiometer base and the lead wire contacts (6) set into recesses in the base (1) so that they make proper contact with the potentiometer winding.

CAUTION

Do not disassemble balance potentiometer assembly unless absolutely necessary, and do not remove the collector ring from the balance potentiometer base. If it is determined that some portion of this assembly should be replaced, it is advisable to replace the complete assembly.

(i) (See figure 331.)—Remove the four flat-head screws (14) and countersunk external tooth lock washers from the wiper clutch friction clamping washer (4). Remove the clamping washer, the clutch friction collar (3), and the wiper clutch mounting plate (2).

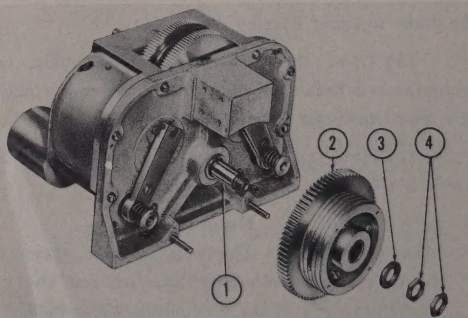
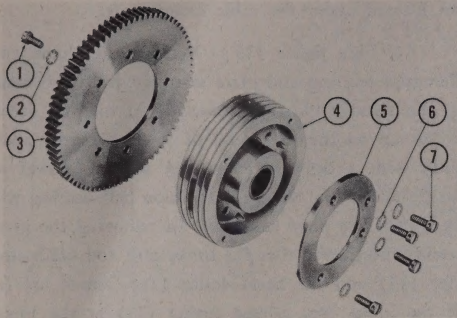


Figure 333 — Cable Drum Removed

Index No.	Nomenclature
1.	Cable Drum Shaft
2.	Cable Drum Assembly
3.	Washer
4.	Nuts

Figure 334 — Cable Drum Disassembled



Index No.	Nomenclature
1.	Screws
2.	Lock Washers
3.	Cable Drum Gear
4.	Cable Drum Sub-Assembly
5.	Control Cable Clamping Washer
6.	Lock Washers
7.	Screws

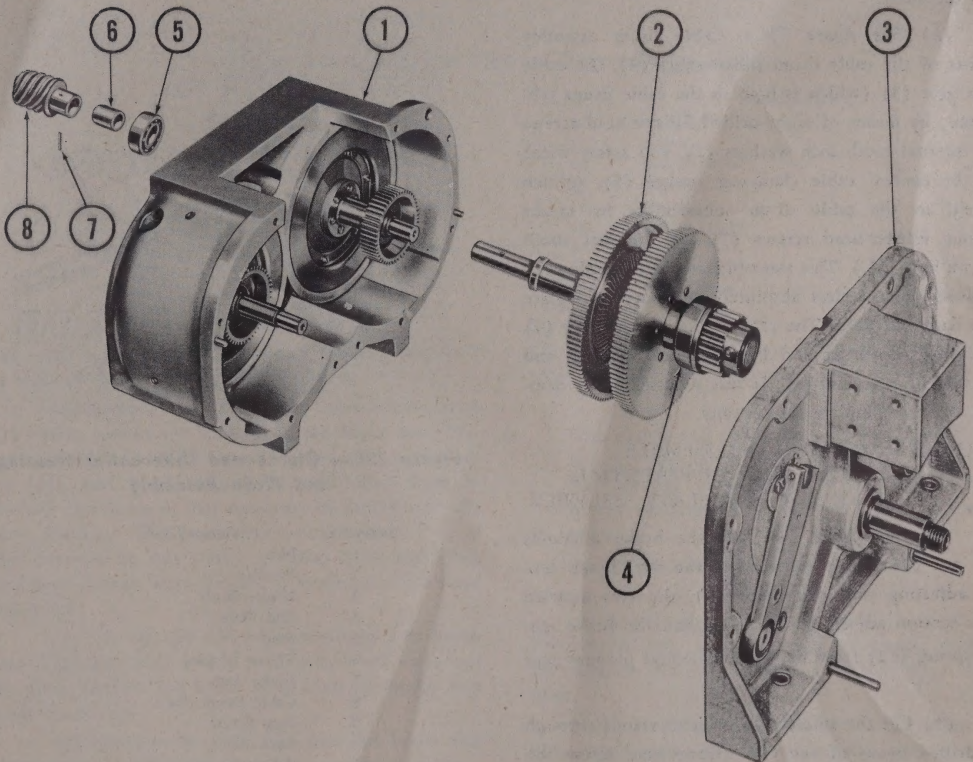


Figure 335 — Clutch and Differential Housing End Plate Removed

Index No.	Nomenclature
1.	Housing
2.	Differential Assembly
3.	End Plate Assembly

Index No.	Nomenclature
4.	Bearing
5.	Bearing
6.	Spacer Sleeve

Index No.	Nomenclature
7.	Tapered Pin
8.	Drive Worm

(10) REMOVE CABLE DRUM ASSEMBLY.

Note

Servo units are often removed from the air-plane by removing the cable drum from the unit and leaving it attached to the control cables of the plane through the use of a dummy servo unit. In this case, the unit will come in for overhaul without the cable drum in place. All cable drums will not fit all servo units. For interchangeability information see T.O. 11-60AA-6.

(a) (See figure 333.)—Remove the two nuts (4) and plain washer (3) from the end of the cable drum shaft (1). Remove the cable drum assembly (2) from the shaft.

(b) (See figure 334.)—Cable drum assembly consists of the cable drum subassembly (4), the cable drum gear (3) (which is held to the cable drum subassembly by means of eight drilled fillister-head screws (1), internal tooth lock washers (2), and safety wire) and the control cable clamping washer (5), (which is held to the cable drum subassembly by means of four fillister-head screws (7) and internal tooth lock washers (6).) This assembly should not ordinarily be disassembled unless absolutely necessary to replace some damaged part. The cable drum subassembly (4) consists of the drum and flanged sleeve bearing and *must not* be disassembled. If this subassembly is damaged, replace complete subassembly.

(11) REMOVE AND DISASSEMBLE
CLUTCH AND DIFFERENTIAL
HOUSING END PLATE ASSEMBLY.

(a) (See figure 336.)—If the brake solenoids have not been removed, remove the two brake tension adjusting nut lock nuts (10), the two knurled brake tension adjusting nuts (11), and the brake tension spring (12) from the brake solenoid plunger pull rods.

(b) Cut the safety wire which extends through the drilled heads of the two fillister-head screws located directly under the cable drum shaft.

(c) (See figure 335.)—Remove the 9 remaining fillister-head screws and lock washers which secure the clutch and differential housing end plate assembly (3) to the housing (1). Note that there are screw spacers

under the heads of the two screws, with the drilled head located under the cable drum shaft.

(d) (See figure 336.)—Remove the clutch and differential housing end plate assembly from the housing. To remove the plate assembly, it may be necessary to tap on the front end of the differential shaft lightly with a light hammer and wooden dowel so that the differential shaft drive pinion ball bearing will slide out of the plate assembly. In removing the plate assembly, be careful that the brake pull rod plain stop collar (14) and the bevel collar (13), which are inside the brake arm release spring (15) at the lower end of the brake arm (7), do not fall out. These collars are carefully fitted for this particular servo unit

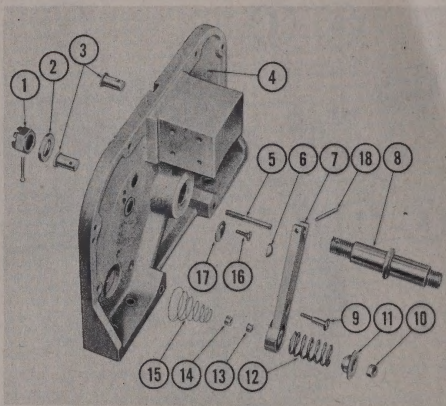


Figure 336—Clutch and Differential Housing
End Plate Assembly

Index No.	Nomenclature
1.	Nut
2.	Washer
3.	Hinge Studs
4.	End Plate
5.	Stud
6.	Thrust Bearing
7.	Brake Arm
8.	Cable Drum Shaft
9.	Stop Screw
10.	Lock Nut
11.	Adjusting Nut
12.	Brake Tension Spring
13.	Bevel Stop Collar
14.	Plain Stop Collar
15.	Brake Arm Release Spring
16.	Shoulder Screw
17.	Oil Hole Cover
18.	Hinge Pin

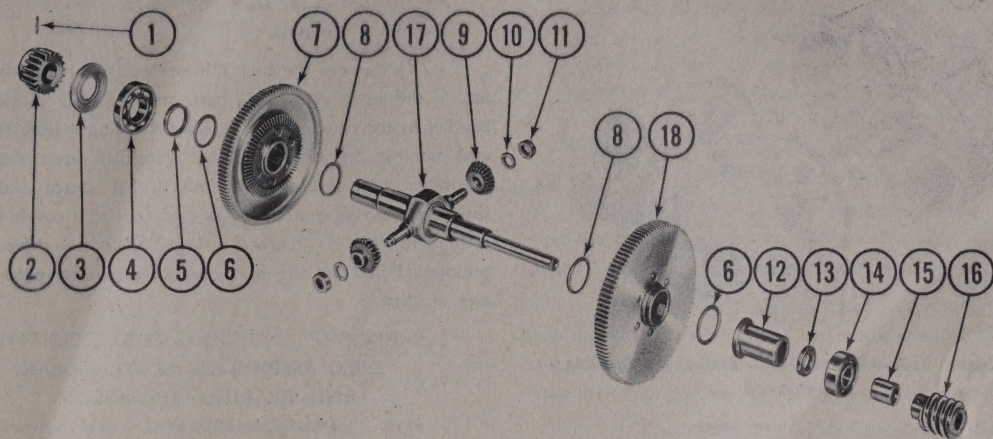


Figure 337 — Exploded View of Differential Assembly

Index No.	Nomenclature	Index No.	Nomenclature
1.	Pinion Dowel Pin	10.	Spacing Washer
2.	Pinion	11.	Collar
3.	Bearing Baffle	12.	Spacer Collar
4.	Bearing	13.	Bearing Spacer
5.	Bearing Spacer	14.	Bearing
6.	Shaft Spacer	15.	Spacer Sleeve
7.	Front Differential Drive Gear Assembly	16.	Worm
8.	Spacing Washer	17.	Crosshead
9.	Crosshead Pinion	18.	Rear Differential Drive Gear Assembly

and should be marked in removal so that they may be replaced in exactly the same position.

(e) Remove the two brake arm stop screws (9) which restrict the motion of the brake arm (7). Lift out the brake arm thrust bearing (6), plain collar (14), and bevel collar (13), and place them in marked containers so that they may be replaced in the same position. The brake arm release spring (15) is also removed at this time. (Collars (13) and (14) may have already been removed if brake solenoids were removed.)

(f) Cut off one end of each of the two brake arm hinge pins (18) with a cutting tool and drive out the pins. Remove the brake arms from the brake arm hinge studs (3).

(g) Remove the cotter pins from the brake arm hinge studs (3); remove the brake arm hinge studs.

(b) Remove the shoulder screws (16) holding the two oil hole covers (17) to the plate subassembly; then remove the oil hole covers.

(i) Remove the cotter pin from the end of the cable drum shaft (8); remove the nut (1) and washer

(2) which secures it in place. Drive out the cable drum shaft from the plate subassembly.

Note

This clutch and differential plate subassembly is a matched unit with the clutch and differential housing subassembly; if either unit requires replacement, both units must be replaced.

(12) REMOVE AND DISASSEMBLE THE DIFFERENTIAL ASSEMBLY.

(a) (See figure 335.)—Support the limit shaft drive worm (8). Using a small pin punch, drive out the tapered pin (7) which secures this worm to the shaft.

(b) Holding the limit shaft drive worm with one hand, pull out the differential assembly (2), taking care not to allow the differential shaft rear ball-bearing spacer sleeve (6) to fall out. Then remove the spacer sleeve.

(c) (See figure 337.)—Disassemble the differential assembly by drilling or filing off and driving out the cable drum drive pinion pin (1). Scribe the

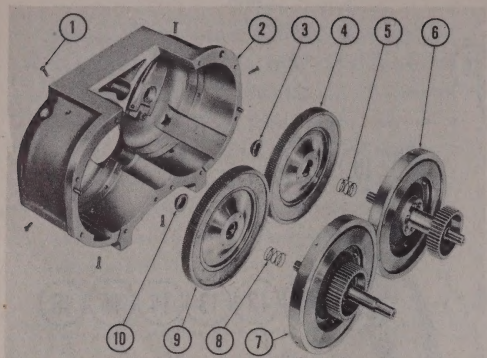


Figure 338 — Clutch and Brake Assemblies Removed

Index No.	Nomenclature
1.	Screw
2.	Housing
3.	Clutch Thrust Collar
4.	Right-Hand Clutch Gear Assembly
5.	Clutch Release Spring
6.	Right-Hand Clutch Disc Assembly
7.	Left-Hand Clutch Disc Assembly
8.	Clutch Release Spring
9.	Left-Hand Clutch Gear Assembly
10.	Clutch Thrust Collar

pinion and shaft so they may be reassembled in the same position. Remove the pinion (2), the drive pinion ball-bearing baffle (3), the drive shaft pinion ball bearing (4), the front bearing spacer (5), the shaft spacer washer (6), the front differential drive gear assembly (7), and the spacing washer (8) from the front end of the shaft. From the other end of the shaft, remove the rear ball-bearing spacer (13), the differential shaft spacer collar (12), the spacer washer (6), the differential drive gear assembly (18), and another spacer washer (8). The worm (16) and spacer sleeve (15) have already been removed, and the rear ball bearing (14) has remained in the housing. Drive out the tapered pins which pass through the collars (11) holding the differential crosshead pinions (9) to the cross-head (17). Remove the pins, collar, spacing washers (10), and pinions. The differential shaft and pinion cross-head forms a complete assembly and *must not be disassembled*.

Note

Use particular care in disassembling the differential assembly to carefully mark the position of all spacing washers, as considerable time

can be saved in reassembly if spacing washers are replaced in the same position from which they were removed.

(d) Remove the four fillister-head screws which attach the limit cam shaft base and terminal block bracket to the clutch and differential housing assembly, and remove the bracket. Then carefully press the worm-end ball bearing (14) out of the clutch and differential housing assembly, and place it in a covered container, properly marked. Also, place the drive-pinion-end ball bearing in a covered container, properly marked.

(13) REMOVE AND DISASSEMBLE CLUTCH DISC ASSEMBLIES, CLUTCH GEAR AND BEARING ASSEMBLIES. (See figure 338.)

(a) (See figure 338.) Remove the six flathead screws (1) which secure the left and right-hand clutch disc assemblies (6 and 7) to the housing (2). Place scribe marks on each brake ring and on the housing to make alignment of these parts easier in reassembly.

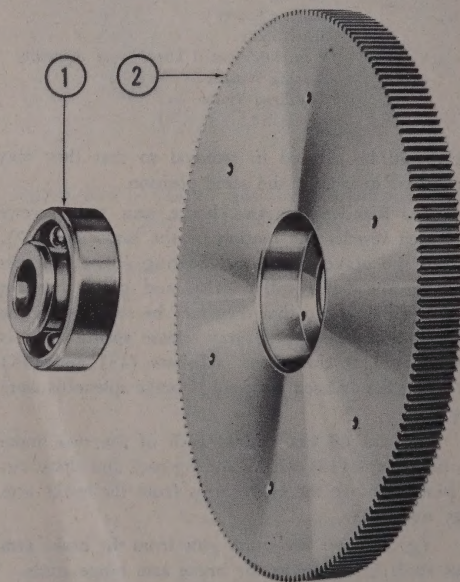


Figure 339 — Clutch Gear Assembly

Index No.	Nomenclature
1.	Bearing
2.	Gear

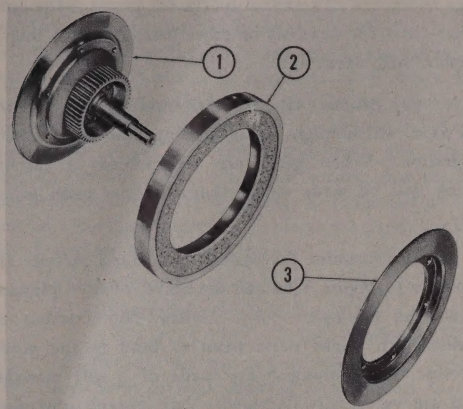


Figure 340 — Left-Hand Clutch Disc Assembly

Index No.	Nomenclature
1.	Clutch Disc
2.	Brake Ring Assembly
3.	Brake Disc

(b) Using a thin wooden dowel inserted so that it bears against the end of the clutch shaft, tap lightly on the dowel to free the clutch disc assemblies so that they may be lifted out of the housing.

(c) The parts removed with each shaft include the clutch thrust collars (3 and 10), the clutch gear (8), and the clutch disc assemblies (6 and 7). Slip the thrust collars off the shafts, being careful to place them in a container marked "left collar" (10) and "right collar" (3), so that it may be replaced in exactly the same position. Then slip the gear and bearing assemblies off of the shafts, marking them "left" (9) and "right" (4), and the clutch release springs (8 and 5). The remaining parts comprise the clutch disc assembly.

(d) (See figure 339).—Disassemble the gear assemblies by removing the bearing (1) from the gear (2), using a small pin punch through the holes provided to drive on the outer race. As soon as the bearing is removed, place it in a covered container, properly marked, so that it may be reinstalled in the same location.

CAUTION

Do not attempt to remove the clutch gear cork insert from the gear assembly. This cork is cemented in place and ground down in a special machine to provide an absolutely flat surface to engage the clutch disc. Therefore, if corks are damaged, the entire clutch gear

assembly should be replaced, *unless such grinding equipment is available*. Do not touch the clutch gear cork, or allow it to become dirty, since it will then require additional cleaning before reassembly.

(e) DISASSEMBLE THE CLUTCH DISC ASSEMBLIES. (See figures 340 and 341.)

1. Place a scribe mark on the brake disc (3) and the clutch disc (1) so that the two may be fastened together again in exactly the same position.

2. Remove the six fillister-head screws which secure the brake disc (3) to the clutch disc and shaft assembly (1). Remove the brake disc and the brake ring assembly (2) from the clutch disc shaft assembly.

3. The clutch disc shaft assembly (1) consists of the clutch disc, the operating shaft gear, and the operating shaft, combined as a riveted assembly, and *must not be disassembled*. If any damage is noted on this assembly, the entire assembly must be replaced.

CAUTION

Do not attempt to remove the brake ring cork inserts from the brake ring assembly. This cork insert is cemented in place and ground down in a special machine to provide an absolutely flat surface to engage the brake

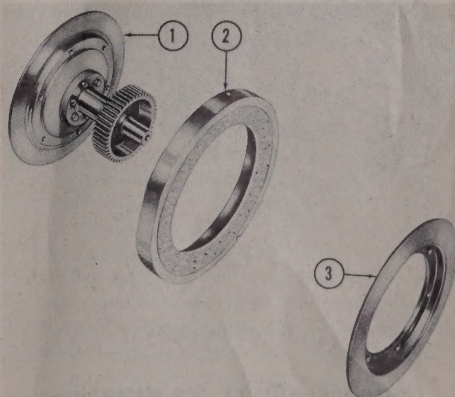


Figure 341 — Right-Hand Clutch Disc Assembly

Index No.	Nomenclature
1.	Clutch Disc
2.	Brake Ring Assembly
3.	Brake Disc

disc. Therefore, if corks are damaged, the entire brake ring assembly should be replaced, *unless such grinding equipment is available*. Do not touch the brake ring cork, or allow it to become dirty, since it will then require additional cleaning before reassembly.

(f) Left-hand and right-hand clutch and brake assemblies are identical except that the left-hand clutch disc shaft assembly (1, *figure 340*) includes a gear with a short hub, and the right-hand clutch disc shaft assembly (1, *figure 341*) has a gear with a long hub.

(g) (See *figure 342*).—Remove the two clutch arm assemblies by removing the two fillister-head screws (4) which hold each arm assembly in place. Separate the arms (1) from the hinges (2) by cutting off one end of each of the arm hinge pins (3) and driving them out.

d. CLEANING, INSPECTION, TESTING, AND REPAIR.

(1) INSPECT PARTS FOR NOTICEABLE DAMAGE.—Inspect all disassembled parts of the servo unit for any damage which might hinder its functioning as part of the assembled unit. Examine all cast-

ings as well as all terminal blocks for cracks. Examine other parts for scratches or other damage which might impair their operation.

(a) Examine all gear teeth carefully for scratches or nicks which might cause binding and impair their operation. When gears are reassembled, a careful check will be made to see that all gears mesh properly.

(b) Examine the operating solenoid plunger assemblies (5, *figure 326*) and the brake solenoid plunger assemblies (8, *figure 330*) carefully for scratches or nicks which might cause them to bind in the guide sleeves. These plungers are made of a soft material and are very easily damaged. Very smooth operation is essential to the proper operation of the servo unit. Examine the brake solenoid plunger pull rods carefully. Check them with a straightedge to make sure they have not become bent. Straighten rods, if necessary. Clean plungers and bushings carefully and test for fit and freedom of plunger in the bushing.

(2) SOLENOID WINDINGS.—Examine the condition of the brake and operating solenoid windings (7, *figure 326* and 5, *figure 330*), giving particular attention to the lead wires and the lugs at the end of these wires. Make sure that lugs are solidly attached and that insulation on windings and wires have not been damaged. Using an ohmmeter, carefully check the resistance of each winding. Correct resistance value and permissible tolerance are given in the table of resistance values, *figure 142A*. These windings are designated as F7 and F8 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the winding.

(3) SPARK SUPPRESSING CONDENSER ASSEMBLY.—Carefully examine these condensers (9, *figure 325*) to see that the cases are not cracked. Check them with an ohmmeter to make certain that they are not shorted. Pay particular attention to the lead wire and the terminal lug on the end of the wire to make certain that the wire and lug are not damaged and that a good contact is made.

(4) CLUTCH AND BRAKE ARMS, THRUST BEARINGS, AND COLLARS.—Carefully examine for burrs or scratches in the recess in the clutch arm assembly (1, *figure 342*) into which the clutch thrust collar (3 and 10, *figure 338*) fits. Carefully examine

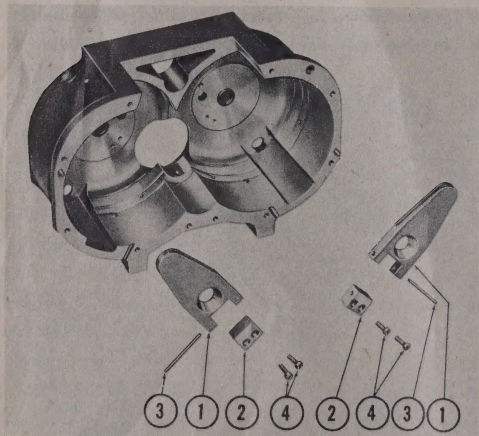


Figure 342 — Clutch Arm Assemblies

Index No.	Nomenclature
1.	Arm Assembly
2.	Hinge
3.	Hinge Pins
4.	Screws

the clutch thrust collar for burrs. Fit the collar into the arm assembly, moving it about carefully in the recess to test by feel for any roughness of operation. If roughness of operation is detected, or if burrs are noted, replace the damaged part. Carefully examine the brake arms (7, figure 336), giving particular notice to the recess into which the brake arm thrust bearing (6) fits. Insert the thrust bearing into the recess, and move it about to check for roughness of operation. If rough operation, or damaged parts, are detected, replace the damaged parts.

(5) CLUTCH GEAR AND
BEARING ASSEMBLY AND
CLUTCH DISC SHAFT ASSEMBLY.

(a) Remove the clutch gear bearings (1, figure 339) from their covered containers, and insert in the gear assembly (2) from which they were removed. Slip each clutch gear assembly over its respective clutch disc shaft assembly. With the clutch engaged, check to see that the inner race of the clutch gear ball bearing protrudes about .012 inch above the shoulder on the clutch disc shaft. This inner race must protrude above the shoulder on the shaft so that the clutch thrust collar will contact only the inner bearing race, and clearance will be provided between the collar and the shoulder of the shaft. Any clearance less than .012 inch at this point will be due to wear on the clutch gear cork. If the cork is worn to a point where only a scant clearance is provided, the clutch gear and cork assembly should be replaced.

CAUTION

Do not attempt to remove the clutch gear cork from the clutch gear or the brake ring cork from the brake ring. These corks are cemented in place; then the surface of the cork is ground down on a special machine to give an exact flat cork surface to engage the clutch disc. *Unless such a special machine is available*, the entire clutch gear and cork assembly, or brake ring assembly, should be replaced if the corks are unsatisfactory.

(b) Carefully examine clutch gear corks for damage to the cork surface. Replace any assemblies in which the corks are nicked, or are otherwise damaged. Make sure that the vent holes in the gear are open, and if necessary, clean these out with a wire.

(c) Clean the clutch gear cork with a soft brush saturated with carbon-tetrachloride (U. S. Army Specification No. 4-503-110B).

(d) Examine the cork on the brake ring assembly (2, figure 340 and 341) for damage. Replace this entire assembly if the cork is damaged in any way unless special grinding machines are available.

(e) Clean the cork and brake ring assembly

with a soft brush saturated with carbon-tetrachloride (U. S. Army Specification No. 4-503-110B).

(f) Inspect the clutch disc and brake disc for burrs or other damage, particularly on the polished friction surface which contacts the cork. Wash all discs thoroughly in carbon-tetrachloride (U. S. Army Specification No. 4-503-110B).

CAUTION

Cleanliness of these corks will materially effect the operation of the servo unit. Once the corks have been cleaned, care should be taken to protect them from dust, dirt, or foreign particles. The friction surface must not be touched with the fingers.

(6) CABLE DRUM ASSEMBLY.—The cable unit drum subassembly (4, figure 334), which consists of the cable drum and the plain sleeve bearing in the drum, form a complete assembly; if either part is damaged, both must be replaced. Carefully examine these parts for damage of any kind. Wash all parts of the assembly, including the cable drum gear, in carbon-tetrachloride (U. S. Army Specification No. 4-503-110B). Place the cable drum subassembly over the cable drum stud to test the fit of the drum assembly on the stud. The drum must fit snugly on the stud, but must turn freely. There must be a slight amount of end play of the drum on the shaft when secured in place.

(7) LIMIT SWITCH MOUNTING BASE ASSEMBLY.—Wash the limit switch blade assembly and the limit switch contact bracket assembly in carbon-tetrachloride (U. S. Army Specification No. 4-503-110B) and polish contact points if necessary.

(8) POTENTIOMETER. (See figure 332.)

Note

Servo units used on the AT-11 airplane are fitted with a 90-degree potentiometer assembly instead of the regular 180-degree potentiometer assembly. With the aid of an ohmmeter, it is easy to determine which type of potentiometer is used on the particular servo unit being overhauled. Connect the ohmmeter between the black and white leads to the potentiometer. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. The 180-degree potentiometer is designated as R13 and the 90-degree as R14 in the table. Only if an ohmmeter is not available should the potentiometer be taken apart for identification. Figure 343 shows the different types of lead wire contacts which are used to give the 180-degree and 90-degree "effective" areas on the potentiometer.

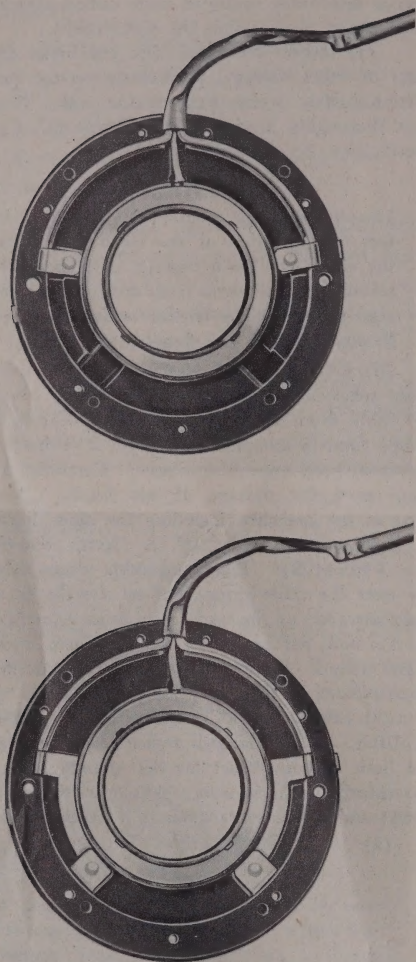


Figure 343 — 180 Degree and 90 Degree Potentiometers

(a) Carefully examine the potentiometer assembly to make sure that the potentiometer base (1) has not become cracked. If cracked or damaged in any way, it should be replaced.

(b) Carefully examine the potentiometer winding (3) for dents or scratches which might hinder its operation. If winding is damaged in any way, replace the entire winding.

(c) Make sure that the potentiometer lead wires (2) are soldered tightly to the contacts (6) which contact the potentiometer winding, and to the terminal

lugs at the opposite ends of the wire. Continuity should be checked carefully with an ohmmeter. Replace wires if insulation is damaged.

(d) Clean the surface of the potentiometer winding carefully using a clean, dry cloth. The cloth may be slightly moistened with alcohol if necessary. A toothbrush may be used to brush out the winding if care is taken to brush parallel to the wires of the winding only.

CAUTION

A very fine polishing paper (0000) may be used very lightly on the potentiometer windings if absolutely necessary to get a clean contact surface.

(e) Using an ohmmeter, check the resistance of the potentiometer. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. The 180-degree potentiometer is designated as R13 and the 90-degree as R14 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the potentiometer. This resistance check must be taken with the potentiometer assembly assembled so that the resistance is obtained from one potentiometer contact to the other. In the reassembly operation, the potentiometer will be checked for cleanliness and shorted turns.

(f) Carefully examine the potentiometer wiper assembly. Replace if it appears to be bent or damaged, or if the contacts are worn.

(9) DIFFERENTIAL ASSEMBLY.

(See figure 337.)

(a) The differential shaft and the differential cross-head pinion assembly (17) are matched parts and must *not* be disassembled. If any damage is noted to either of these parts, the entire unit should be replaced. The cable drum drive pinion (2) and the limit shaft drive worm (16) were fitted to this assembly after it was assembled, and the holes for the pins which secure them to the shaft were drilled at that time. *Therefore, the pinion and worm must be considered as part of the shaft and cross-head assembly.* All of these parts must be replaced together if any one is found to be defective.

CAUTION

The two differential shaft ball bearings (4 and 14) are part of this carefully fitted differential assembly. To replace these bearings without carefully fitting new bearings to this particular position may cause serious trouble. Since the spacer collar and washers on the differential shaft are assembled so that there will be no end play, it is absolutely essential

that when any of these parts, bearings, or washers are replaced, they be replaced with parts of exactly the same length along the shaft.

(b) Wash all parts of the differential assembly in carbon-tetrachloride (U. S. Army Specification No. 4-503-110B). Inspect and clean the bearings in accordance with the section, paragraph 2, *d*, (1) and (2). Examine the gears for nicks or burrs; replace gears where necessary.

CAUTION

If any parts of the differential assembly require replacement, particular care must be exercised in following the steps outlined for the reassembly of this assembly, in this section, paragraphs 4, *e*. Keep all parts of the differential assembly in marked containers so that they may be reassembled in exactly the same position from which they were removed. This will make the necessary adjustments in reassembly considerably easier.

(10) MOTOR ASSEMBLY. (See figure 329.)

(a) Carefully examine brush holders (2, 13) to see if they have become damaged. Brush holders will not ordinarily be removed in disassembly, unless they require replacement. Whenever new brushes are installed, brushes must be fitted to the commutator by running the motor for a few minutes and then removing the brushes and scraping at the points of contact until an even contact is obtained over the entire end of the brush. Measure the length of the brush. If the brush length is less than $\frac{3}{8}$ -inch, the brush should be replaced. Clean brushes (1) carefully by wiping them with a clean dry cloth. Clean brush holders with a piece of cloth wrapped around a match stick or a piece of stiff wire, and wipe out the interior of the holder, or wash the brush holders in carbon-tetrachloride (U. S. Army Specification No. 4-503-110B.) If the brush spring or brush lead wire is damaged, or the plug has damaged threads, replace the brush assembly.

(b) The armature and commutator assembly (6) should be cleaned and tested for open circuit, grounded armature, and shorted armature. The commutator should be closely inspected, as outlined in this section, paragraphed 2, *d*, (15), (*e*).

(c) Carefully examine the field coils (7) to make sure they have not been overheated to an extent which might hinder their operation. Using an ohmmeter, test the resistance of the field coils. Correct resistance value and permissible tolerance are given in the table of resistance values, figure 142A. These coils are designated as F6 in the table. If resistance is found to be outside of the limits prescribed in the table, replace the coils.

(11) BEARINGS.—Inspect and clean bearings, as outlined in this section, paragraph 2, *d*, (1) and (2).
e. REASSEMBLY.

Note

Reassembly instructions on the servo unit have been arranged in the reverse order of the disassembly instructions. Thus, if only parts on the front side of the differential housing assembly (potentiometer, cable drum, clutch assemblies, and brake assemblies) have been disassembled, reassembly is accomplished by performing steps (1) through (5) in this reassembly procedure and also steps (9), and (14) through (20). If only the electrical parts on the back of the unit (operating solenoids, brake solenoids, and motor) have been disassembled, only steps (6) through (14), and (16) through (20) need be performed in reassembly. Remember that the left-hand and right-hand sides of the unit are the left and right-hand sides when viewing the unit from the cable drum end.

CAUTION

Make sure any parts not kept in covered containers are free from dirt before reassembly.

(1) ASSEMBLE AND INSTALL CLUTCH

ARM ASSEMBLIES. (See figure 342.)

(a) Insert new clutch arm hinge pins (3) through the clutch arms (1) and clutch arm hinges (2); crimp the end of the hinge pin so that it will stay securely in place.

(b) Check carefully to see that the hinge turns freely on the hinge pin.

(c) Using two 4-40 x 7/16-inch fillister-head screws (4), attach each clutch arm assembly to the clutch and differential housing subassembly.

CAUTION

Before tightening these fillister-head screws, sight through the hole in the housing subassembly through which the operating solenoid push rod extends, and line this hole up exactly with the indentation in the clutch arm assembly into which the push rod must fit. Then tighten the screws holding the clutch arm assembly to the housing subassembly.

(2) ASSEMBLE AND INSTALL CLUTCH

DISC ASSEMBLIES AND CLUTCH

GEAR AND BEARING ASSEMBLIES.

(a) (See figure 339).—Remove the clutch gear ball bearings (1) from the covered containers into which they were placed after cleaning and lubrication;

insert each ball bearing into its respective clutch gear (2). Be sure that the protruding side of the inner bearing race is installed away from the cork of the clutch gear assembly.

(b) (See figures 340 and 341.)—Assemble the two clutch disc assemblies by first slipping the brake ring assembly (2) over the gear on the clutch disc shaft assembly (1), and then by slipping the brake disc (3) over the gear. See that scribe marks on the clutch disc (1) and the brake disc (3) line up and that all left-hand parts were assembled with the left-hand clutch disc shaft assembly, and that the right-hand parts are assembled to the right-hand clutch disc assembly. Note that the flat edge of the ring must be toward the center, and the cut-out notch must be on the side where the brake rod passes. Attach it to the clutch disc shaft assembly (1) with six 3-48 x 1/4-inch fillister-head screws.

CAUTION

See that these screws are pulled up tight. Much damage can be caused if they loosen in operation.

(c) (See figure 338.)—Place a drop of oil on the clutch disc shafts on the end opposite the shaft gear. Then slip the clutch release springs (5 and 8) over this end of the shaft. Be sure that only one drop of oil is used and that it is spread evenly over the shaft so that it will not drop down on the clutch disc surface.

(d) Slip each clutch gear and bearing assembly (4 and 9) over this end of the clutch disc shaft from which it was removed. Slip a clutch thrust collar (3 and 10) on the shaft behind the gear and bearing assembly, taking care that the flat side of the clutch thrust collar bears against the inner race of the clutch gear ball bearing. Use the same thrust collar that was removed from the shaft unless corks are new or very worn. These clutch thrust collars are provided in three different thicknesses. If, after assembly, it is determined that there is insufficient clearance between the clutch arm assembly and the clutch gear and bearing assembly, or the housing subassembly, a different thickness should be used.

(e) Insert the left-hand gear and bearing assembly and clutch disc assembly into the left-hand side of the housing subassembly, taking care that the clutch thrust collar does not drop off the end of the shaft and that the brake ring assembly seats properly in the housing subassembly, so that the brake rod will fall exactly in the center of the cut-out portion of the ring assembly. Secure the ring assembly in place in the housing subassembly, using three 3-48 x 3/8-inch flathead screws (1).

(f) Insert the right-hand gear and bearing assembly and clutch disc assembly into the right-hand

side of the housing subassembly in the same manner. Secure in place with three 3-48 x 3/8-inch flathead screws (1).

CAUTION

Extreme care will have to be used in seating the brake ring assembly in the housing subassembly, since they fit quite snugly into place and have to be tapped into place with a soft hammer. For this reason it is extremely important that the ring assembly be so positioned that the holes for the attaching screws will line up exactly with the holes in the housing subassembly when seated properly. Carefully aligning the scribe marks made in disassembly will make this operation easier.

(3) ASSEMBLE AND INSTALL DIFFERENTIAL ASSEMBLY.

Note

The reassembly of all parts of the differential assembly in the same position from which they were removed will make assembly and adjustments considerably easier.

(a) (See figure 337.)—Slip a cross-head pinion gear (9) over each end of the cross-head (17); then slip a differential pinion washer (10) over the end of the cross-head on top of each pinion. Place the two cross-head pinion retainer collars (11) in position, and insert the cross-head taper pins through the collars and cross-head.

(b) Turn each cross-head pinion to see that it runs free on the cross-head. If the pinion does not turn freely, the taper pin and collar (11) must be removed and the pinion washer (10) replaced with a thinner washer. If the pinion runs free, check the end play of the pinion on the cross-head with a thickness gage as shown in figure 344. End play at this point should be not more than .003 inches. If more than this amount of end play is present, remove the taper pin and collar (11) and replace the pinion washer

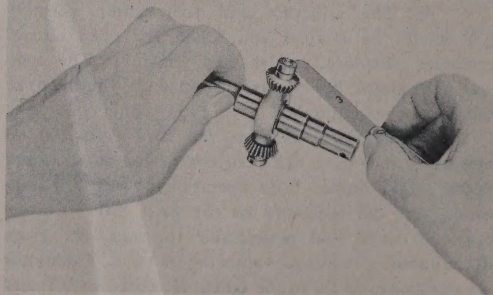


Figure 344 — Checking End Play of Pinion on Crosshead

(10) with a thicker washer until the pinion runs free, but does not have more than .003 inch end play.

(c) Place a differential shaft spacer washer (8) .034 inch thick over each end of the differential shaft. (If no parts have been replaced, use washers removed from these positions.) Place a differential drive gear assembly (7 and 18) over each end of the shaft. Press the two gears tightly together by hand to see that there is no binding when they are rotated as shown in figure 345. If binding occurs, a thicker spacer washer must be used.

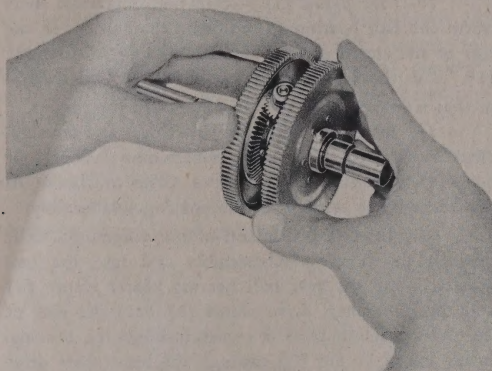


Figure 345 — Testing Differential Gears for Binding

(d) (See figure 337.) Slip the differential shaft front bearing spacer (5) on the front end of the shaft, and the spacer collar (12) on the rear end of the shaft. Holding these *tightly* against the shoulders of the shaft, as shown in figure 346, measure with a thickness gage the end play of the gear assemblies on the shaft; that is, the space between the front bearing spacer and the front gear, and the space between the rear spacer collar and the rear gear. Then insert a spacer washer (6) having a thickness of approximately .002 inch less than the measured end play between the front gear (7) and bearing spacer (5), and the rear gear (18) and spacer collar (12). Check end play of each gear to be sure it now falls within the limits of .001 to .003 inch.

(e) Slip the differential shaft drive pinion ball bearing (4) on the front end of the shaft, making sure that the bearing fits snugly, but may be pushed into place with the finger. When removing this bearing from its covered container, do not re-lubricate, since it was properly lubricated when cleaned and inspected. Then slip the differential shaft drive pinion ball-bearing baffle (3) onto the front end of

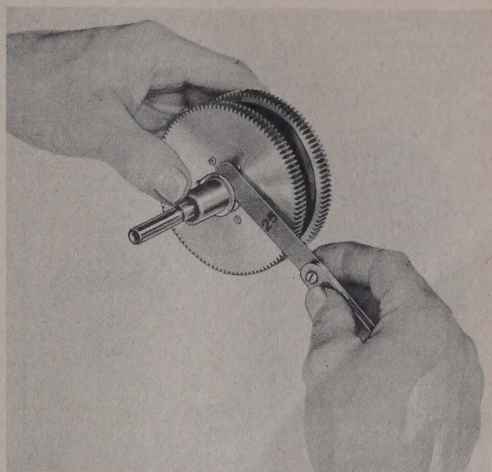


Figure 346 — Measuring End Play to Determine Spacer Thickness

the shaft, making certain that the raised shoulder on the baffle rests against the inner race of the ball bearing (4). Insert the cable drum drive pinion (2) over the front end of the differential shaft.

CAUTION

If neither the front spacer (5), the drive pinion ball bearing (4), nor the drive pinion ball-bearing baffle (3) have been replaced and they are exactly the same parts which were removed from this differential assembly, the cable drum drive pinion dowel pin (1) may be inserted. Then there will be *absolutely no end play* between any of these parts, as the front bearing spacer (5) seats tightly against the shoulder on the shaft. If any of the above parts required replacement, it will be necessary to select-fit all of these parts so that there will be no end play at this point when the pinion dowel pin is in place in the pinion and shaft.

(f) Line up the scribe marks on the cable drum drive pinion and the differential shaft. Insert a new cable drum drive pinion dowel pin through the pinion and shaft. Stake this pin in place.

WARNING

This dowel pin must be ring-staked into place in accordance with the specifications outlined in figure 347. If this pin is not staked into place exactly in accordance with these instruc-

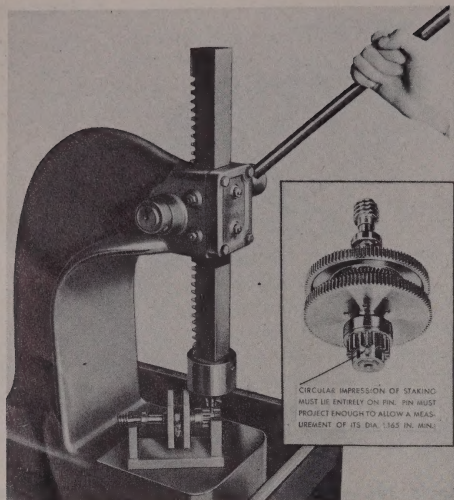


Figure 347 — Staking Cable Drum Drive Pinion Dowel Pin

tions, it may loosen and jam the cable drum pinion and gear, which, in turn, will lock the control surfaces of the airplane in which this servo unit is installed. Therefore, use extreme care in staking this pin into place. The lives of the planes entire crew may depend on this single overhaul operation.

On Norden Servo Units, a slightly different method of staking this dowel pin into place is used. A dowel pin having a length less than the diameter of the cable drum pinion hub is used, and, after the pin is inserted, it is staked securely in place by making center punch marks around the edge of the hole in the pinion hub to close up the hole so that the pin cannot come loose.

(g) (See figure 337.)—Slip the differential shaft rear ball-bearing spacer (13) onto the rear of the shaft against the spacer collar (12) so that the raised shoulder on the spacer will be away from the gear. Then slip the differential shaft worm-end ball bearing (14) into place against this spacer and the rear ball-bearing spacer sleeve (15) over the shaft against the bearing. Place the limit shaft drive worm (16) in place on the shaft.

CAUTION

If none of these parts have been replaced, the taper pin which secures the worm to the shaft may be put in place. There will be *absolutely*

no end play between any of these parts, as the shaft spacer collar fits up tight against the shoulder on the shaft. If any of these parts have been replaced, it will be necessary to select-fit all of these parts carefully so that the taper pin which secures the worm to the shaft will fit exactly into its hole, and there will be absolutely no end play between the parts.

(b) Remove the taper pin from the worm and shaft. Remove the worm (16), rear ball bearing sleeve (15), and the rear bearing (14). This bearing (14) is to be installed in the housing subassembly.

(i) (See figure 335.)—Slip the differential shaft worm end ball bearing (5) into the counterbore in the rear of the clutch and differential housing subassembly (1). This should fit snugly, but should be free enough so that it may be pushed into place with the fingers.

(j) Install the limit cam shaft base and terminal block bracket to the housing subassembly, using four 4-40 x 1½-inch fillister-head screws. This bracket holds the bearing (5) securely in the housing subassembly.

(k) Insert the rear end of the differential shaft through the housing subassembly and into the ball bearing. Slip the rear ball bearing spacer sleeve (6) and the limit shaft drive worm (8) onto the rear of the differential shaft as it comes through the bearing. Insert the taper pin (7) through the limit shaft drive worm and the differential shaft, taking care that the holes in both the worm and shaft taper in the same direction as the pin when it is installed. Tap the pin firmly into place with a soft hammer.

(4) ASSEMBLE CLUTCH AND DIFFERENTIAL HOUSING END PLATE ASSEMBLY.

(See figure 336.)

(a) Press the cable drum shaft (8) into the end plate subassembly (4), using an arbor press. Secure it in place with the castle nut (1) and cable drum shaft washer (2) and a cotter pin.

(b) Insert the brake arm hinge studs (3) through the end plate subassembly. Secure each stud in place with a cotter pin.

(c) Place the brake arms (7) over the brake arm hinge studs. Insert the brake arm hinge pins (18) through the arms and the studs. Crimp each brake arm hinge pin on each side where it projects from the brake arm, using a crimping tool, which will flatten the shaft without bending it.

CAUTION

Use extreme care in crimping this pin, as any slight bend in the pin will cause it to bind in the hinge stud. The brake arm must be absolutely free at this point.

(d) Install the two operating shaft oil hole covers (17), using the two shoulder screws (16) provided. Be careful that the shoulder screws screw in against the end plate and that the oil hole cover turns freely about the shoulder screw when the screw is tightly in place. If the potentiometer bracket mounting studs (5) have been removed, screw them tightly into place.

(5) INSTALL END PLATE ONTO CLUTCH AND DIFFERENTIAL HOUSING ASSEMBLY. (See figure 335.)

(a) Carefully place the end plate assembly (3) in place on the housing assembly (1), taking care that the differential shaft drive pinion ball bearing (4) slides properly into place in the end plate assembly, and that the housing dowel pins enter the holes provided in the end plate assembly.

(b) Secure the end plate assembly to the housing assembly, using screws and washers, as follows: Consider the attaching screw holes as numbered in a clockwise direction, as shown in figure 348.

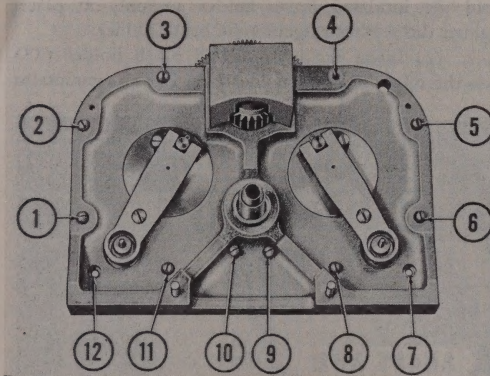


Figure 348 — Attaching Screws for End Plate Assembly

1. Insert four 6-32 x 11/16-inch fillister-head screws with internal tooth lock washers into holes Nos. "1", "2", "5" and "6".

2. Install a 6-32 x 11/16-inch fillister-head screw with drilled head and internal tooth lock washer into hole No. "3" and two 6-32 x 11/16-inch drilled fillister-head screws with internal tooth lockwashers and screw spacers into holes Nos. "9" and "10". A fourth 6-32 x 11/16-inch drilled fillister-head screw and internal tooth lock washer will later be installed in hole No. "4" when the balance potentiometer lead wire guard is installed in this position.

3. Install two 6-32 x 7/16-inch fillister-head screws with internal tooth lock washers into holes Nos. "8" and "11". Fillister-head screws with spring lock washers will be installed in holes Nos. "7" and "12" when the base assembly is installed.

(c) After all screws are tightened, check to be sure that differential gears rotate freely.

(6) INSTALL BRAKE SOLENOID ASSEMBLIES AND ADJUST BRAKE ARM OVER-TRAVEL.

(a) (See figure 330.)—Using two 6-32 x 1/2-inch flathead screws (6), attach each brake solenoid housing (7) to the clutch and differential housing assembly. Use care to see that the openings from which the winding wires emerge from the solenoid housings are toward the inside.

(b) Insert a brake solenoid winding (5) in each brake solenoid housing (7), taking care that the lead wires from the winding fall into the openings provided.

(c) Insert the brake plunger guide sleeves (4) into the windings.

(d) (See figure 336.)—Insert a brake solenoid plunger assembly through the guide sleeve; allow the threaded portion of the pull rod to protrude from the clutch and differential gear housing end plate assembly. Choose a brake arm thrust bearing (6), and insert it into the hemispherical recess in the brake arm (7). A drop of light oil will aid in holding the thrust bearing in place.

(e) Slip a brake pull rod plain stop collar (14) (approximately .145 inch thick) over the end of each pull rod. Slip a brake pull rod bevel collar (13) over each pull rod, with the bevel portion toward the brake arm (7). Slip a brake arm release spring (15) over each pull rod, with the large end inserted in the counterbore of the end plate. (See figure 349.)

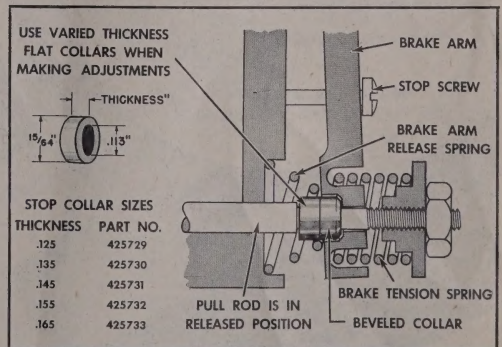


Figure 349 — Spacing Collars Provide Brake Adjustment

(f) (See figure 336.)—Slide plunger and pull rod back so that the pull rod may be inserted into the hole in the brake arm. Place the brake arm tension spring (12) over the end of the rod and screw on the knurled adjusting nut (11) until the spring is slightly compressed. Screw the cover on the solenoid housing; tighten securely, using the spanner wrench assembly.

(g) Press lightly on the adjusting nut (11) until a distinct resistance is felt. This indicates that the brake disc has made contact with the brake cork. By applying an additional force, the knurled adjusting nut should move in further until the brake plunger seats itself in the solenoid housing. The magnitude of this additional movement (which is called "the brake arm over-travel") is controlled by the thickness of the thrust bearing (6) in the brake arm (7) and by the length of the plain collar (14) on the brake pull rod. This over-travel is not affected by the amount of compression of the brake spring (12). This over-travel must be between the limits of $1/64$ and $3/64$ inch (approximately $1/32$ inch, see figure 350.)

(h) (See figure 336.)—Measure the brake arm over-travel carefully with a scale as shown in figure 350. If insufficient over-travel is noted, correct it by using a thicker thrust bearing (6), or a thinner plain collar (14). If too much over-travel is indicated, correct by using a thinner thrust bearing (6), or a thicker

plain collar (14). It will be necessary to remove the adjusting nut and spring from the brake pull rod and the cover from the brake solenoid housing when changing either the thrust bearing or the plain collar, since the brake plunger must be withdrawn enough to allow the brake arm to be raised up to provide access to either the thrust bearing or the plain collar. When this adjustment has been properly made, screw the brake solenoid housing cover securely into place, and attach the short ground lead from each brake solenoid winding to the brake solenoid cover assembly, using two 4-40 x $3/16$ -inch binding-head screws with plain washers.

(7) ASSEMBLE AND INSTALL
MOTOR ASSEMBLY.

(a) (See figure 329.)—Slip the insulated brush holder (2) into the insulator tube (3). Press the insulated brush holder assembly into the commutator end frame (4) on the side provided with the tapped holes for the headless setscrews which hold the insulated brush holder assembly in place. Push the holder in all the way against the shoulder of the insulating tube.

(b) Insert the two headless setscrews which hold the insulated brush holder assembly in place; tighten the setscrews against the brush holder.

(c) Insert the noninsulated brush holder (13) into the opposite brush holder hole in the commutator

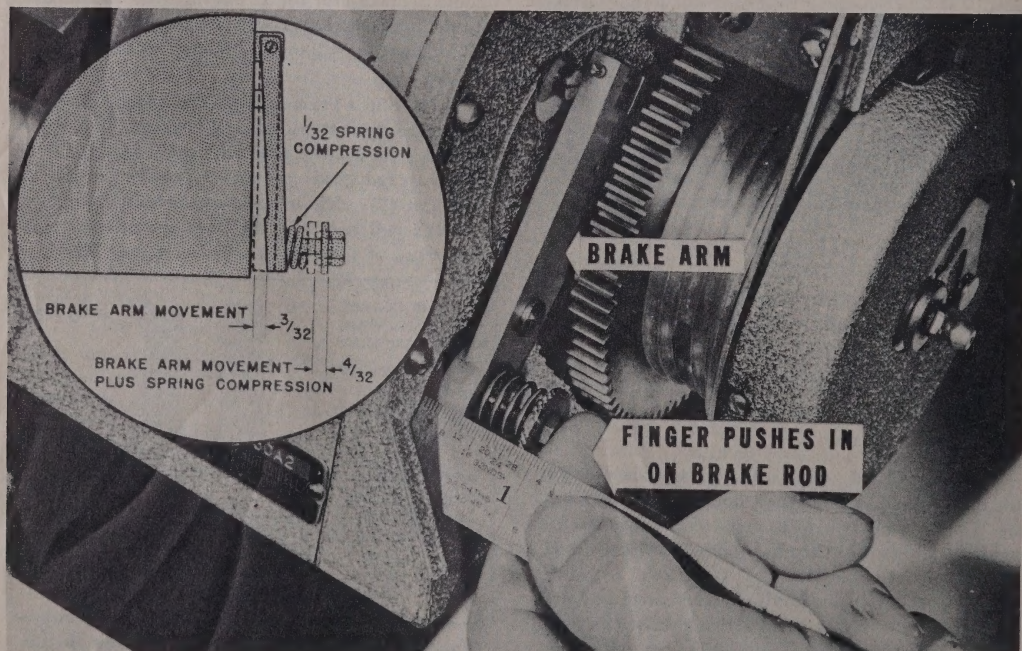


Figure 350 — Adjusting Brake Arm Over-travel

end frame (4). Press it all the way in against the shoulder on the brush holder.

(d) Insert a pole-piece (8) through each field coil (7). Insert the field coil and pole-piece assemblies into the field ring assembly (11), taking care that the lead between the two field coils is opposite the locating pins which fit into the slots in the end frame assemblies (4 and 10).

(e) Secure each pole-piece to the field ring assembly with two 6-32 x 1/2-inch flathead screws. Stake the field ring into the screw slots to lock the screws in place.

(f) Insert the field coil insulator under the edges of the two pole-pieces so that it will be between the lead wire extending from one field coil to the other and the pole-pieces and armature.

(g) Remove the armature ball bearings (5 and 12) from the covered containers into which they were placed after cleaning, inspection, and lubrication; press the bearings onto the armature shaft.

Note

These bearings were lubricated when they were cleaned and inspected, and no additional lubrication is required at this time.

(b) Attach the short ground lead wire from the field ring assembly to the commutator end frame assembly, using a 4-40 x 1/4-inch round-head screw and medium spring lock washer. Then insert the two leads from the field ring assembly through the hole provided in the commutator end frame assembly, and place the end frame assembly onto the field ring, making sure that the locating pin in the field ring lines up and falls into the slot provided in the end frame assembly. Make certain that the ground lead from the field coil falls behind the field coil insulator after the commutator end frame assembly has been put in place on the field ring assembly.

(i) Replace any shims removed from under the commutator end ball bearing, and insert the armature assembly. These shims provide for end play adjustment.

(j) Slip the pinion end frame (10) over the pinion end ball bearing on the armature. Press it into place, taking care to line it up so that the locating pin on the field ring assembly (11) falls into the slot in the pinion end frame.

(k) Insert the four motor through-bolts (14) from the commutator end into the tapped holes in the pinion end frame. Screw these bolts up tight to clamp the end frames to the field ring assembly. A lock washer must be inserted under the head of each through-bolt.

(l) Measure the end play of the motor armature, using a depth micrometer, inserted through the

hole in the commutator end against the end of the armature shaft. This end play should be from .003 to .008 inch. If the end play is not within these limits, disassemble the motor, and add or remove shims from under the commutator end ball bearing.

(m) Insert the armature brush assemblies (1) into the brush holders, taking care that the brush with the two scribe marks goes on the uninsulated side which also was scribed with two marks, and that the brush with a single scribe mark into the insulated brush holder. Be sure that the brush is inserted so that the scribe marks are on the same side and correspond to the scribe marks made on the brush holders in disassembly so that the curvature on the brush will fit the commutator properly and the brush will be in exactly the same position as it was before removal. Screw the brush holder cap into the brush holder after inserting the springs carefully into the holder. Test the action of the brush against the spring, but be careful not to snap the brush against the commutator as this may damage the carbon brush.

(n) Using a spring balance calibrated in ounces, measure the spring tension on the brushes at the point when contact with the commutator is broken, as shown in figure 351. This should be from 3 to 4 ounces. There is no adjustment for tension on the brushes; however, if the tension does not fall within these limits, it may be necessary to stretch (or compress) the brush spring, or to replace the brush assembly. An ohmmeter connected across the brushes will give an indication of exactly when contact with the commutator is broken.

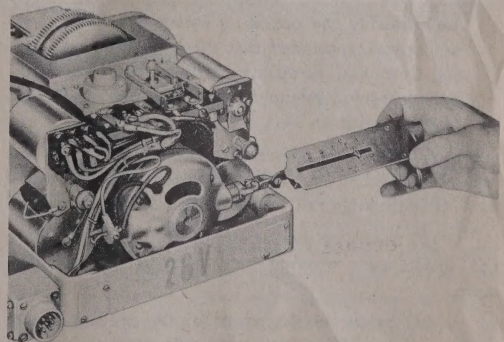


Figure 351 — Measuring Brush Spring Tension

(o) Attach the two brush lead wires to the brush holder caps, using two 3-48 x 3/16-inch round-head screws with medium spring lock washers. Form the brush leads so that the lead wires come out straight from the hole in the brush cap to prevent the

lead wire from catching on the cap as the brush wears down in operation. With a 3-48 x 1/4-inch binding-head screw and medium spring lock washer, fasten the two field coil leads together to the insulated brush holder cap.

(p) Connect the motor lead wire to a 26-volt d-c power source and run the motor to check for speed and quietness of operation. Speed should be checked with a stroboscopes tachometer and should be between 2250 and 2750 rpm. Noisy operation may be due to improperly fitted bearings, defective bearings, or improperly fitted brushes. A noisy motor may be overlooked if not actually tested before it is installed in the housing subassembly, as gear noise will drown out motor noise. Bearing and gear noises are easier to identify in the completed unit on final test if the motor is known to be quiet.

(q) (See figure 328.)—Slide the motor into place on the clutch and differential housing subassembly. Secure it to the housing subassembly with four 6-32 x 11/16-inch fillister-head screws with internal tooth lock washers.

(8) INSTALL OPERATING SOLENOID ASSEMBLY. (See figure 326.)

(a) Using two 6-32 x 1/2-inch flathead screws (8), attach the operating solenoid housings (2 and 10) to the clutch and differential housing assembly. Be sure that the housing scribed with an "L" (10) is installed on the left side, and the one scribed with an "R" (2) is installed on the right.

Note

In installing the operating solenoid housings and covers, remember that the left-hand housing cover may be stamped with an "R" while the right-hand solenoid housing cover may be stamped with an "L".

(b) Insert an operating solenoid winding (7) in each solenoid housing, taking care that the lead wires from the windings fall into the opening provided.

(c) Insert an operating solenoid plunger sleeve (6) inside each winding, and press it securely into place.

(d) Screw on the covers of the operating solenoid housings, taking care that each cover is installed on the housing to which it is matched. Using the spanner wrench assembly, as shown in figure 327, tighten the cover securely on the operating solenoid housings.

(9) ADJUST TRAVEL OF BRAKE ARM.

(a) (See figure 326.)—Insert operating solenoid push rod (9) into one of the operating solenoids, and insert the operating solenoid plunger assembly (3, 4, 5) into this same solenoid.

Note

Be sure that the rounded end of the operating solenoid push rod (9) enters the solenoid first, so that it is the rounded end, and not the tapered end, that contacts the clutch arm. Replacement of push rods in the same side from which they were removed will make adjustment easier.

(b) (See figure 352.)—Connect a 26-volt d-c power source to the two leads from the brake solenoid on the side being adjusted, and also to the two leads from the operating solenoid, making provision to make and break the contact on the operating solenoid.

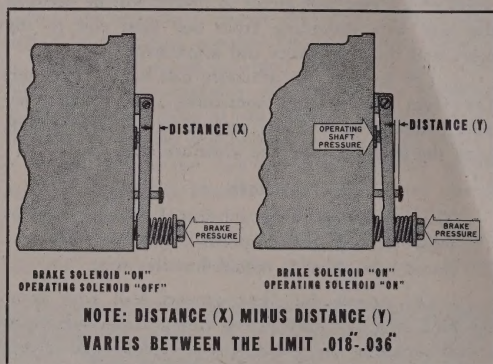


Figure 352 — Brake Release Travel is the Outward Movement of the Brake Arm When the Clutch is Engaged

(c) The brake solenoid will now be energized and the brakes are applied. Make and break the circuit to the operating solenoid so that the travel of the brake arm may be measured at the stop screw, as shown in figure 353. When the operating solenoid is energized, the plunger moves inward. The first part of its motion forces the clutch gear against the clutch disc. The remainder of its motion forces the brake disc (attached to operating shaft) away from the brake cork, compressing the brake tension spring. The brake release travel is the movement of the operating shaft or brake disc from its position. This brake release travel, measured at the brake arm stop screw, should be from .012 to .036 inch. This travel may be measured with a thickness gage, as shown.

(d) (See figure 326.)—If brake release travel is not within these limits, it will be necessary to replace the operating solenoid push rod (9) with a longer or shorter rod to bring the brake release travel within the prescribed limits. A shorter rod will give less brake release travel. A longer rod will give more brake release travel.

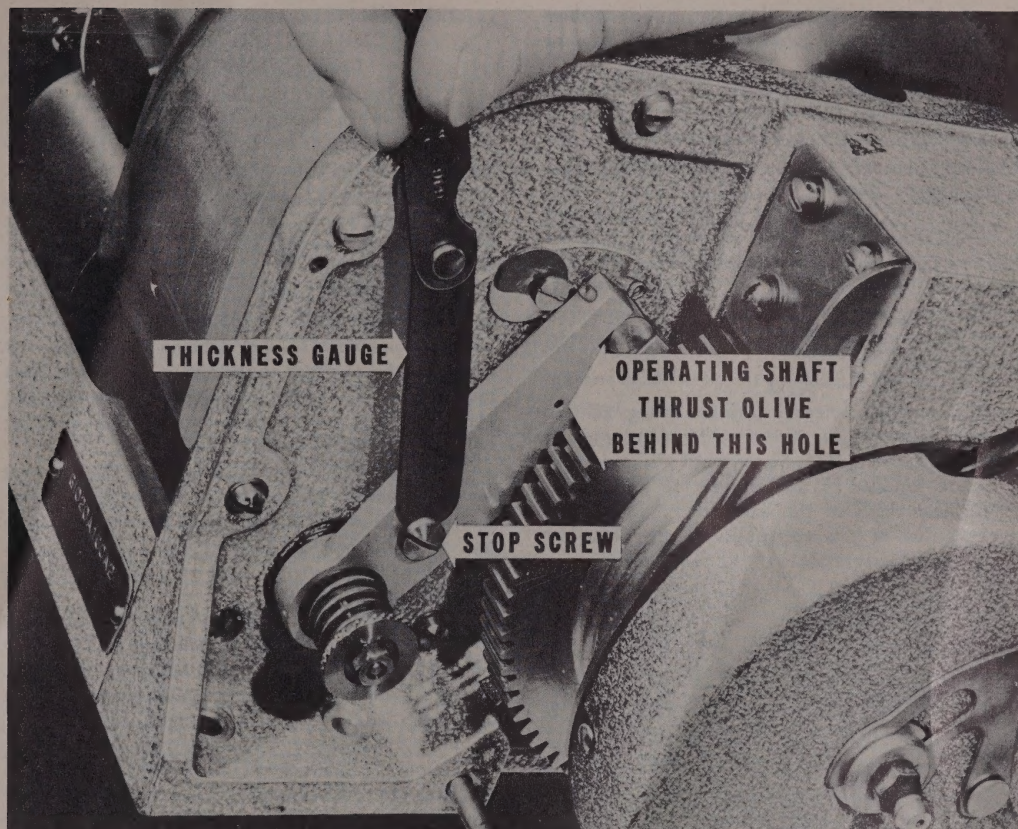


Figure 353 — Adjusting Brake Arm Travel

(e) Repeat the above steps to adjust the brake release travel on the opposite side to within the limits of from .012 to .036 inch at the stop screw.

**(10) ASSEMBLE AND INSTALL
OPERATING SOLENOID
BACK-UP PLATE ASSEMBLIES**

(a) (See figure 325.)—Fasten the suppressing condenser mounting plate (10) to the operating solenoid back-up plate assemblies (7 and 11), using two 6-32 x $\frac{3}{8}$ -inch fillister-head screws in each. Insert a condenser (9) in the condenser clamp; place the lug of the short lead wire from the condenser under the outside fillister-head screw.

(b) Be sure that the 4-40 x $\frac{1}{2}$ -inch fillister-head screw (13) and hex nut (12) are on the solenoid plunger rocker arm assemblies (5); then slip the assemblies over the stud of the back-up plate subassembly (7 and 11). Slip the back-up plate spring (4)

over the stud, and screw the spring adjusting nut (3) and the self-locking nut (2) onto the stud.

(c) Insert the rocker arm fulcrum plates (6) under the rocker arms so that the rocker arms fall into position on the plate. Place the balance potentiometer terminal block (1) in place on top of the right-hand fulcrum plate. Secure the terminal block to the back-up plate subassembly (7), using two 3-48 x 7/16-inch flathead screws (8). Rim stake these screws in place. Make sure that the L-shaped terminal strips are in place on the block.

(d) Insert the operating solenoid plunger assembly through the back-up plate assembly so that the two fingers of the rocker arm assembly (5, figure 325) fall between the engaging washer (4) and the plunger (5). (See figure 326.)

(e) Insert the right-hand plunger into the right-hand solenoid. Secure the back-up plate assembly to the solenoid housing cover, using two 4-40 x $\frac{3}{4}$ -inch

fillister-head screws with medium spring lock washers extending through the terminal block and back-up plate assembly.

(f) (See figure 326.)—Insert the left-hand plunger assembly through the plunger back-up plate so that the fingers on the rocker arm fall between the rocker arm engaging washer (4) and the plunger (5) on the plunger assembly.

(g) Insert the left-hand plunger assembly into the left-hand solenoid. Attach the back-up plate assembly to the solenoid housing cover, using two 4-40 x 3/4-inch fillister-head screws and internal tooth lock washers, taking care to insert the lug of the 4-inch ground lead under the attaching screw which is nearest to the motor.

Note

The operating solenoid back-up spring adjusting nut (3, figure 325) should be left loose and is not actually adjusted until the servo unit is installed in the airplane. In making the final check of the servo unit, however, the action of this adjustment at this point can be properly made.

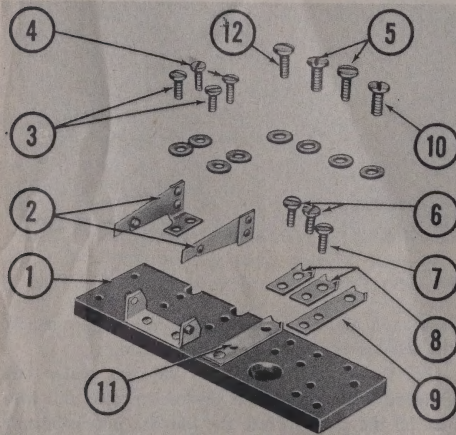


Figure 354 — Limit Switch Mounting Base Assembly

Index No.	Nomenclature
1.	Mounting Base
2.	Contact Blade Assemblies
3.	Screws
4.	Screws
5.	Screws
6.	Screws
7.	Screw
8.	Terminal Strips
9.	Terminal Strip
10.	Screw
11.	Terminal Strip
12.	Screw

(11) ASSEMBLE AND INSTALL LIMIT SWITCH MOUNTING

BASE ASSEMBLY. (See figure 354.)

(a) Install the two short terminal strips (8) on top of the switch mounting base (1), using two 4-40 x 5/16-inch binding-head screws (6) with plain washers inserted in the holes nearest the center of the base. Two 6-32 x 3/8-inch binding-head screws (5) with plain washers may be inserted in the two remaining holes of these terminal strips, but should not be screwed down tight.

(b) Install the left and right limit switch contact blade assemblies (2) on the switch mounting base, using two 4-40 x 3/16-inch binding-head screws (3) in the two holes closest to the center of the base. Two more 4-40 x 3/16-inch binding-head screws (4) with plain washers may be inserted into the two remaining holes, but should not be pulled up tight.

(c) Lay the long terminal strip (9) (which was removed from the base) in place. Insert a 4-40 x 5/16-inch binding-head screw (7) with a plain washer in one end, and a 6-32 x 3/8-inch binding-head screw (10) with plain washer in the other end, but do not pull these screws up tight.

(d) Using four 4-40 x 7/16-inch fillister-head screws, attach the limit switch mounting base assembly to the limit cam shaft base and terminal block bracket.

(12) CONNECT WIRES.—Make connections in accordance with wiring diagram, figure 355.

(a) (See figure 354.)—Bring up the two long leads from the brake solenoids. Attach them both to the long terminal strip (9) on the right-hand side of the limit switch mounting base assembling with the 4-40 x 5/16-inch binding-head screw (7) and plain washer located on the end of the strip toward the clutch and differential housing assembly.

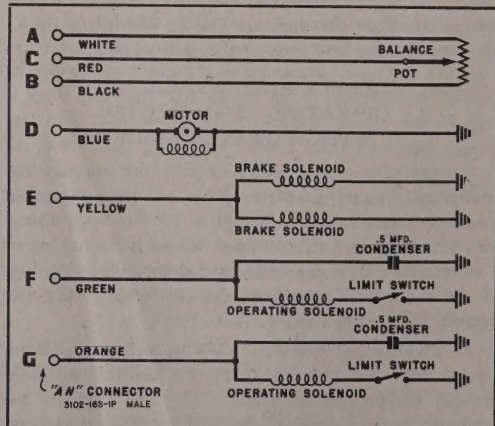


Figure 355 — Wiring Diagram

(b) (See figure 354.) Attach the short leads from the two brake solenoids to the covers of their respective solenoid housings with 4-40 x 1/4-inch binding-head screws and plain washers. These are the ground leads to the brake solenoid windings.

(c) Attach the long lead from the right-hand operating solenoid to the left-hand limit switch contact blade assembly, using a 6-32 x 3/8-inch binding-head screw (4) and plain washer. Attach the short lead from the left-hand operating solenoid to the right-hand limit switch contact blade assembly with a 6-32 x 3/8-inch binding-head screw (4) with plain washer. Note that these two leads cross to connect to the proper blade assembly.

(d) Insert the short lead from the right-hand operating solenoid through the hole in the limit switch mounting base assembly. Attach it to the right-hand short terminal strip (8) on the base assembly. Insert the long lead from the left-hand operating solenoid up through the hole in the limit switch mounting base assembly. Connect this lead to the left-hand short terminal strip (8). Connections to these two strips are made with two 4-40 x 5/16-inch binding-head screws (6) and plain washers, inserted through the holes in the strips which are closest to the clutch and differential housing assembly.

(e) Install the ground wire from the screw attaching the left-hand back-up plate assembly to the left-hand operating solenoid housing cover, to the left-hand long terminal strip (11) on the limit switch mounting base assembly with a 6-32 x 3/8-inch binding-head screw (12) and plain washer. Make this connection at the end farthest from the clutch and differential housing assembly.

(f) Attach the lug of the long lead wire from the left-hand condenser, and the lead (green) from terminal "F" of the AN receptacle to the left-hand short terminal strip (8) on the limit switch mounting base assembly, with a 6-32 x 3/8-inch binding-head screw (5) and plain washer. Make this connection at the end away from the clutch and differential housing assembly.

(g) Connect the long lead wire from the right-hand condenser and the lead wire (orange) from the G-prong of the AN receptacle to the right-hand short terminal strip (8) on the limit switch mounting base

assembly with a 6-32 x 3/8-inch binding-head screw (5) and plain washer. Make this connection at the end away from the clutch and differential housing assembly.

(h) Attach the lead wire (yellow) from the "E" terminal of the AN receptacle to the right-hand long terminal strip (9) on the limit switch mounting base assembly with a 6-32 x 3/8-inch binding-head screw (10) and plain washer. Make this connection at the end away from the clutch and differential housing assembly.

(i) Attach the lug of the lead wire (blue) from the D-prong of the AN receptacle, together with the red and black field coil leads from the motor, to the insulated brush holder cap with a 3-48 x 1/4-inch binding-head screw and medium spring lock washer.

(j) Install the balance potentiometer lead wires from the AN receptacle to the terminal block terminals with 4-36 x 1/4-inch binding-head screws and plain washers. Connect the white lead from the A-prong of the AN receptacle to the right-hand terminal, the red lead from the C-prong of the AN receptacle to the center terminal, and the black lead from the D-prong of the receptacle to the left-hand terminal. When leads from the balance potentiometer are connected to the terminal block, it is only necessary to match the colors of the lead wires to make sure that the white lead from the potentiometer is connected to the same terminal as the white lead from the AN receptacle, and that the red and black leads each match with the red and black leads from the receptacle.

(13) ASSEMBLE AND INSTALL LIMIT CAM SHAFT BASE ASSEMBLY. (See figure 356.)

(a) Slip the lever and button assemblies (5) over the flange studs (12). Secure them in place with the retaining collars (3) and taper pins (4).

(b) Secure the cover retaining collar (7) to the base with four 4-40 x 7/16-inch fillister-head screws (9).

(c) Insert the limit cam and gear shaft (6) through the cam shaft bushing in the base, from the top, and slip the limit cam shaft gear (10) in place on the shaft. Secure the gear to the shaft with the taper pin (11), taking care to line up the taper in the gear and shaft properly. Tap the pin securely into place.

(d) Do not put limit shift cam assembly (1)

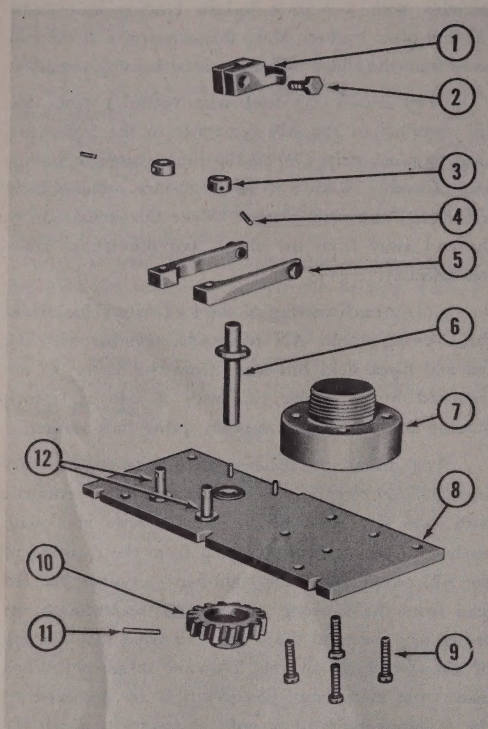


Figure 356 — Limit Cam Shaft Base Assembly

Index No.	Nomenclature
1.	Limit Shaft Cam
2.	Lock Screw
3.	Retaining Collars
4.	Tapered Pin
5.	Lever and Button Assemblies
6.	Cam and Gear Shaft
7.	Cover Retaining Collar
8.	Limit Switch Base
9.	Screws
10.	Limit Cam Shaft Gear
11.	Tapered Pin
12.	Lever Studs

into place until after the servo unit has been tested.

(e) Place the limit cam shaft base assembly in place on the base and terminal bracket, taking care to see that the levers fall on the inside of the two switch contact blade assemblies. Secure the base assembly to

the bracket with four 4-40 x 7/16-inch fillister-head screws.

(14) ASSEMBLE AND INSTALL BASE ASSEMBLY.

(a) The AN receptacle may be installed at any one of four points on the base; and in any one of these positions it may be installed so that the outlet is in any one of five different directions. The proper position and the direction which the outlet must face is determined by the number on the manufacturer's name and type number plate fastened to the base assembly. (See figure 357 and the list below for determination of the proper position of the AN receptacle for the particular servo unit being overhauled.)

Unit Number Found on Base Name Plate	Position	Location
G 1020A 1	C	4
G 1020A 2	B	1
G 1020A 3	C	3
G 1020A 4	A	4
G 1020A 5	D	4
G 1020A 6 or G 1020A 306	C	4
G 1020A 7 or G 1020A 307	C	1
G 1020A 8	C	2
G 1020A 9 or G 1020A 309	B	3
G 1020A 10 or G 1020A 310	A	1
G 1020A 11 or G 1020A 311	C	2
G 1020A 12 or G 1020A 312	D	1
G 1020A 13 or G 1020A 313	D	3
G 1020A 14	A	4
G 1020A 15	D	4
G 1020A 16 or G 1020A 316	C	1
G 1020A 17 or G 1020A 317	B	4
G 1020A 18	D	4
G 1020A 19	A	1
G 1020A 22	B	2
G 1020A 23 or G 1020A 323	D	3
G 1020A 24	B	4
G 1020A 25	A	3
G 1020A 26	A	2
G 1020A 27	B	1

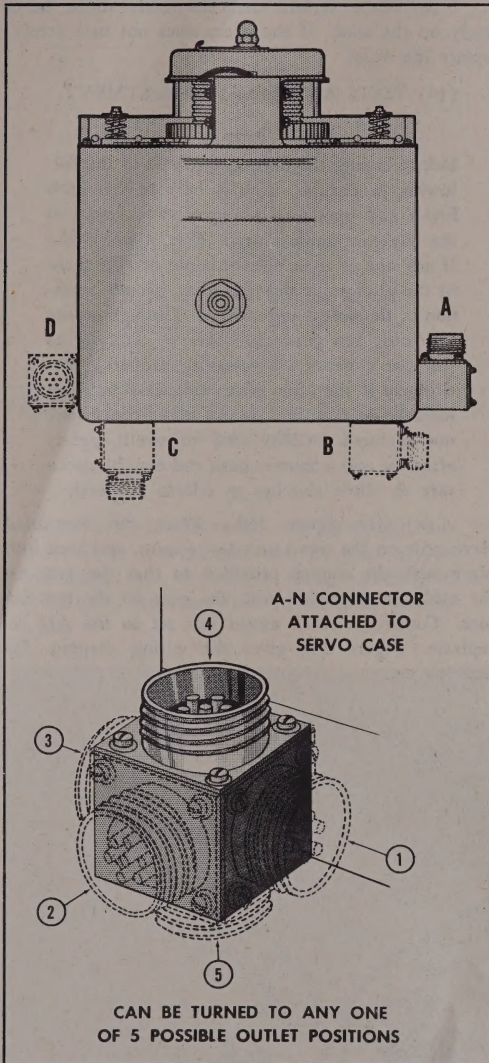


Figure 357 — AN Receptacle Position

(b) Install the AN receptacle adapter to the base at the proper point and with the side opening of the adapter in the proper direction, as indicated in figure 357, using two 4-40 x 5/16-inch fillister-head screws with internal tooth lock washers.

(c) Insert the 7-prong AN receptacle lead wires into the AN receptacle adapter, and into the base. Secure the receptacle to the adapter, using four 4-40 x 3/16-inch fillister-head screws with internal tooth lock washers.

(d) Install the AN receptacle adapter cover, using four 4-40 x 3/16-inch fillister-head screws with internal tooth lock washers. Install the electric outlet auxiliary cover (if they were removed) over the remaining three openings in the base, using two 4-40 x 5/16-inch fillister-head screws in each cover.

(e) Install the base assembly on the clutch and differential housing assembly, using four 6-32 x 7/16-inch fillister-head screws. Secure the base assembly to the end plate assembly with two 6-32 x 7/16-inch fillister-head screws and spring lock washers inserted through the holes "No. 7" and "12" in the end plate assembly. (See figure 348.)

(15) ASSEMBLE AND INSTALL CABLE DRUM ASSEMBLY. (See figure 334.)

Note

All cable drums will not fit all servo units. Refer to T.O. 11-60AA-6 for information concerning replacement.

(a) Secure cable drum gear to cable drum sub-assembly, using eight drilled fillister-head screws (1) and internal tooth lock washers (2).

(b) Safety wire the cable drum screws, as shown in figure 358 and the two end plate screws as shown in figure 359.

WARNING

These screws must be carefully wired according to instructions. Improper wiring may cause serious damage and loss of life.

(c) Insert the cable clamping washer (5) into the cable drum. Secure it in place with four 8-32 x

DRIVE GEAR AND CABLE DRUM

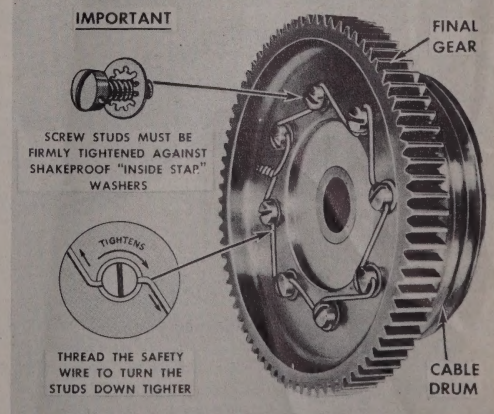


Figure 358 — Safety Wire on Cable Drum

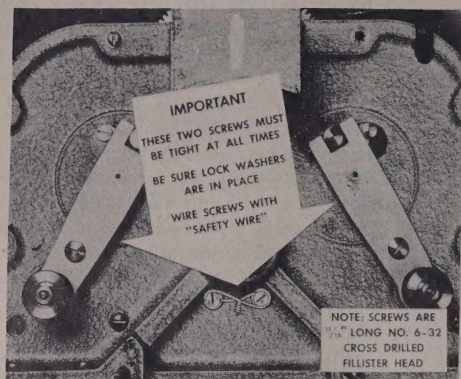


Figure 359 — Safety Wire on End Plate Screws

7/16-inch fillister-head screws and internal tooth lock-washers.

(d) Slide the cable drum assembly over the stud on the end plate assembly, place the cable drum shaft washer over the end of the shaft, and then screw down one of the hex nuts tightly against the washer. Add the lock nut, and screw this down tightly against the first hex nut.

(e) Make certain that the cable drum turns freely on the stud. If the drum does not turn freely, replace the drum.

(16) TESTS AND FINAL ADJUSTMENT.

Note

Before testing the unit, as outlined in the following procedure, check to be sure that both brake and operating plungers slide freely in the plunger guide sleeves (See figure 364.) If any one of these sleeves is out of alignment or the plunger or sleeve is dirty, proper operation of the unit is impossible. Throughout the following test procedure observe carefully to see that clutches are releasing properly, particularly if the same push rods have been re-installed and the clutch and brake corks were not replaced. Corks tend to swell slightly after use and a shorter push rod may be necessary to allow clutches to release properly.

(a) (See figure 360.)—Place the assembled servo unit on the servo unit test fixture, and lock into place with the clamps provided so that the gear on the cable drum meshes with the gear on the test fixture. Connect a servo motor test set to the AN receptacle. Figure 361 gives the wiring diagram for this test set.

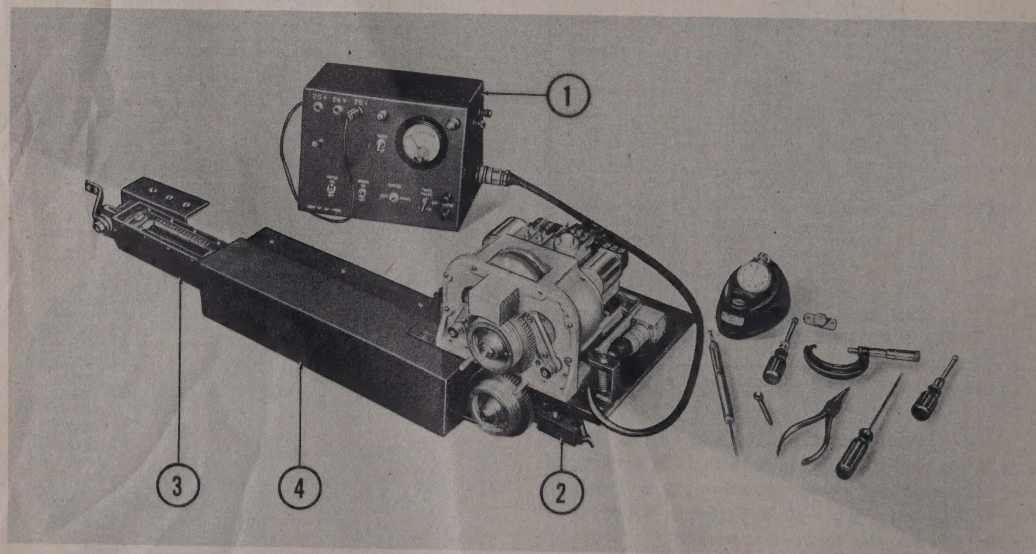


Figure 360 — Servo Unit on Test Fixture

Index No.	Nomenclature
1.	Timer
2.	Disengaging Block

Index No.	Nomenclature
3.	Spring Scale
4.	Guard

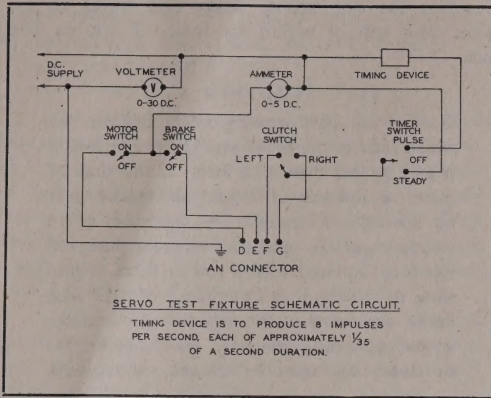


Figure 361 — Servo Unit Test Fixture Schematic Wiring Diagram

Note

The autopilot amplifier and servo unit test set (type G1045) may also be used in performing these tests. Refer to T.O. 11-60AA-5 for complete instructions on its operation and use.

(b) (See figures 349 and 350.)—Check to be sure that there is from 1/32 to 1/64-inch over-travel of the brake plunger after the brake discs have made contact. This adjustment was made previously and is outlined in this section, step (6) preceding.

(c) (See figures 352 and 353.)—Check to make sure that the brake arm travel at the stop pin is within the limits of from .012 to .036 inch. (See step (9) preceding.)

(d) Using a scale, measure the amount of movement of the brake rod from brakes off to brakes engaged position. This "total travel" of the brake rod should be between 7/64" and 9/64". Adjust by different lengths of brake arm stop screw.

(e) Turn motor and brake power switches to "ON". Make sure that there is no excessive arcing of the brushes on the motor commutator. Check the current consumption to the unit with motor and brake power switches at "ON". This must not exceed two amperes.

(f) With the motor and brakes switches "ON" and the scale gear engaged, switch on power to the left clutch by moving the clutch selector switch to the position marked "LEFT", and allow the motor to drive against the spring scale of the fixture until the brake on the right side begins to slip. When this point is

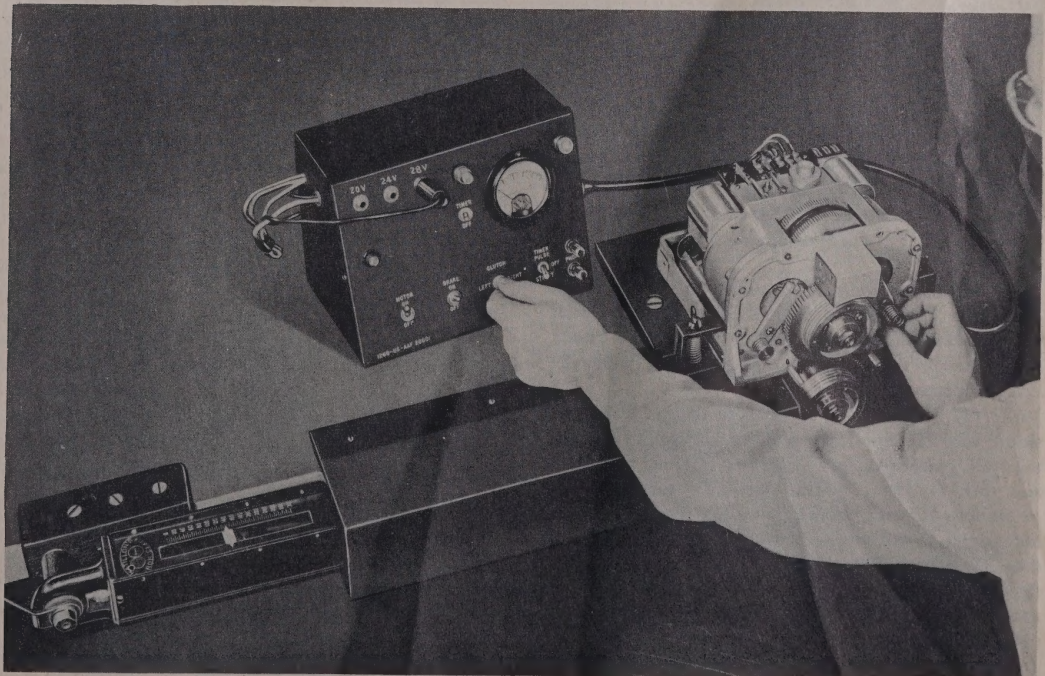


Figure 362 — Adjusting Brake Tension Adjusting Nut

reached, adjust the brake tension adjusting nut on the brake on the right side (opposite the clutch which is energized) until the reading on the spring scale is 140 pounds. (See figure 362.)

(g) Throw the clutch selector switch to the position marked "RIGHT" to turn on the power to the right clutch, and allow the motor to drive the cable drum until the brake on the left side slips. Then adjust the brake tension adjusting nut on the left side (opposite the clutch being tested) until the spring scale reads 140 pounds. Place the clutch selector switch into the "LEFT" position, to energize the opposite clutch, until the spring scale returns to 0; then place the switch in the "OFF" position.

(h) Using a spring scale, against the brake plunger rod, measure the tension of the brake arm tension spring, with the brake power switch in the "OFF" position. This tension should be not over six pounds if these springs have been properly adjusted. (See figure 363.)

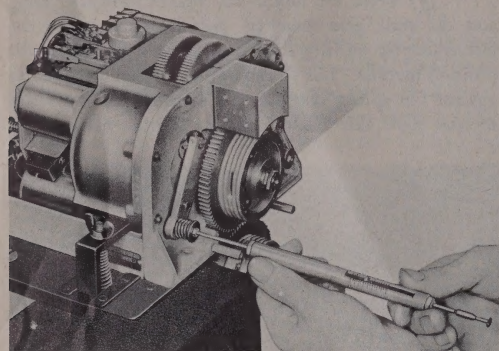


Figure 363 — Measuring Tension of Brake Arm Tension Spring

(i) Check rotation of gears, with each clutch energized. The right clutch shall rotate the differential gear nearest the drum clockwise. The left clutch should rotate the differential gear farthest from the drum counterclockwise.

(j) Place the timer switch in the "PULSE" position, with the motor and brake switches both on, and the scale gear disengaged. Energize first the left clutch and then the right clutch. Check the time of three revolutions of each differential gear. This time shall not exceed 13 seconds, and the difference between the time for each gear should be more than four seconds. If the time of three revolutions of either differential gear exceeds 13 seconds, replace the operating solenoid push rod with a shorter rod, as outlined in step (9) preceding. However, after placing a shorter push rod in place, be sure to measure again the brake arm

travel at the stop screw. Brake arm travel at this point must still be within the limits of .012 to .036 inch.

CAUTION

Do not use an operating solenoid push rod which reduces the brake arm travel at the stop screws to less than .012 inch. If the time of three revolutions of either differential gear on this test still exceeds the maximum of 13 seconds, and the operating solenoid push rod has been replaced with a rod as short as possible to still give the minimum of .012 inch brake arm travel at the stop screw, the clutch is not operating properly, and clutch gear or clutch disc must be cleaned, or replaced.

(k) Reduce voltage to 24 volts. With scale gear engaged, check the pull registered by the spring scale of each clutch when engaged with pulsing action. Each clutch must pull at least 50 pounds. If either clutch does not pull 50 pounds, readjust the brake tension adjusting nut on the opposite side to obtain this minimum pull with pulsing action.

(l) Screw in both operating solenoid back-up spring adjusting nuts as far as possible. With scale gear disengaged, recheck the time of three revolutions for each differential gear. This time must not be less than 25 seconds. If the time is more than this minimum limit, replace the solenoid back-up spring or stretch it slightly to give additional tension. (See figure 364.)

(m) Reduce the voltage to 20 volts, and turn on motor and brake switches. Energize one clutch and then the other. Motor, brakes, and clutches should

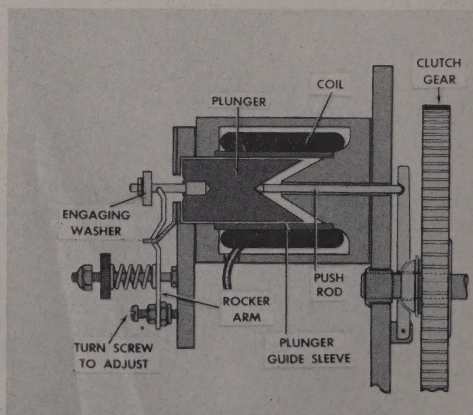


Figure 364 — Operating Solenoid Back-Up Plate Assembly

operate properly on this reduced voltage and, with clutches engaged, should drive the cable drum.

(17) REASSEMBLE AND
INSTALL POTENTIOMETER.

(a) Assemble the potentiometer (if it has been disassembled) by inserting the lead wires into the potentiometer base and inserting the potentiometer into the base so that the lead wires contacts will properly contact the windings of the potentiometer. Then place the potentiometer retaining ring in place. Secure it with seven 4-40 x 5/16-inch round-head screws with internal tooth lock washers. (See figure 332.)

(b) Attach the left and right-hand balanced potentiometer mounting brackets to the potentiometer, using two 4-40 x 1/2-inch fillister-head screws and medium spring lock washers.

(c) Place the wiper clutch mounting plate over the end of the cable drum. Place the wiper clutch friction collar on top of the plate. Secure it to the plate and to the cable drum, using four 4-40 x 5/16-inch flathead screws and countersunk internal tooth lock washers.

(d) Place the potentiometer assembly in place on the servo unit. Secure the brackets to the servo unit with six 6-32 x 5/16-inch drilled fillister-head screws with plain washers. Four of these screws insert in the left-hand bracket, and two of them in the two bottom holes of the right-hand bracket. Do not place the two remaining screws into the top holes of the right-hand bracket until the lead wire guard is in place.

(e) Insert the balance potentiometer lead wire through the hole in the right-hand mounting bracket, and through the hole in the end plate and clutch and differential housing assembly. Place the lead wire guard over the lead wire. Secure the guard in place, using the two remaining 6-32 x 5/16-inch drilled fillister-head screws and plain washers, and a 6-32 x 11/16-inch drilled fillister-head screw and internal tooth lock washer in the "No. 4" hole (See figure 348.) in the end plate. Safety wire the screws holding the potentiometer brackets and the lead wire guard.

(f) Connect the balance potentiometer lead wires to the terminal block on the right-hand operating solenoid plunger back-up plate assembly, matching the colors of the lead wires already to the block; that is, the white lead wire to the same terminal strip as the white lead wire from the AN receptacle, the red to the one to which the red lead is attached, and the black to the one to which the black lead is attached.

(18) INSTALL THE WIPER ASSEMBLY
AND CHECK POTENTIOMETER FOR
CLEANLINESS AND SHORTED TURNS.

(a) Place the wiper assembly on the wiper clutch friction collar so that the long wiper blades are

on the side next to the hole closest to the outside rim of the collar. *Be sure to get this wiper assembly in this position, as it is possible to install the assembly in the reversed position.*

(b) Secure the wiper assembly to the collar, using two 2-56 x 1/4-inch round-head screws and medium spring lock washers.

(c) Using a gram gage under the potentiometer wiper blade, check the tension of the wiper blades which contact the potentiometer and also the blades which contact the collector ring assembly. (See figure 365.) The tension of blades contacting the potentiometer should be from 6 to 15 grams for each blade (18 to 45 grams total), and the tension of the blades contacting the collector ring assembly should be from 10 to 20 grams (20 to 40 grams total). Connect an ohmmeter so that tension can be measured at the exact point at which contact is broken.

(d) Check the potentiometer for shorted turns and cleanliness by first connecting one lead of an ohmmeter to the terminal of the potentiometer terminal block to which the red lead from the collector ring is attached, and the other lead wire of the ohmmeter to either of the other two terminals on the terminal block, that is, to the white or black lead wire. Then move the wiper slowly over the entire arc of contact. Movement must be slow and uniform from one end of the potentiometer to the other. As the wiper moves across the potentiometer, watch the ohmmeter needle carefully. Any fluctuation of the ohmmeter needle indicates dirt on the potentiometer windings. This dirt may usually be removed by wiping the potentiometer with a lint-free cloth. In some cases, however, it may be necessary to moisten the cloth with alcohol; if alcohol is not available, carbon tetrachloride may be used. A tooth brush may be used to brush the winding if care is taken to brush parallel to the winding only. Winding may be rubbed lightly with very fine polishing cloth (0000) if absolutely necessary. Shorted turns are indicated by a hesitation of the needle as the wiper moves across the potentiometer winding. More

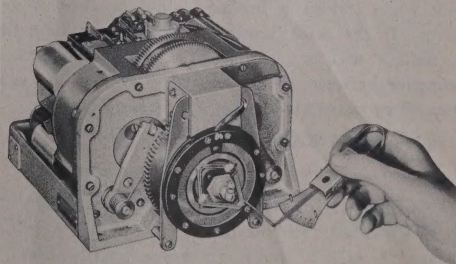


Figure 365 — Checking Tension of Wiper Blades

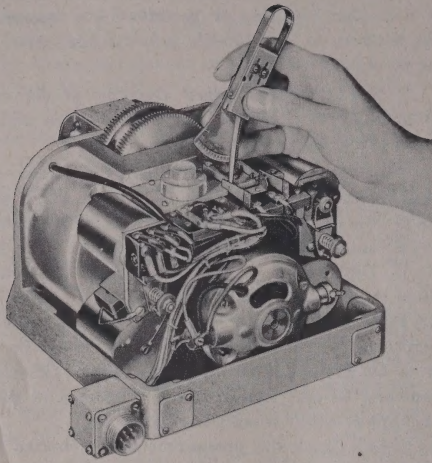


Figure 366 — Checking Tension of Limit Switch Blade Contacts

than 4 consecutive shorted turns in any $\frac{1}{4}$ inch of travel of the wiper over the potentiometer winding will not give satisfactory operation and the potentiometer should be replaced. Extreme care must be used in making this check so that each hesitation of the needle as it moves across the scale may be noted.

(19) CHECK MOTOR BRUSH AND CONTACT TENSION.

(a) Using a gram gage, test the tension of the limit switch contact blade assemblies. (See figure 366.) This tension should be 150 grams minimum. Correct tension, if necessary, by slightly bending the angle to which the blade is mounted. The gap between limit switch blade and operating arm must not be less than .005 inch when contacts are closed and cam is not touching arm.

(b) Check the motor brush tension with a spring scale. (See figure 351.) Brush tension at the point when contact is broken should be from 3 to 4 ounces. If the brush tension is not within these limits, replace with a new brush assembly. Connect an ohmmeter between the two brushes so that the exact point when contact is broken can be measured.

(20) LUBRICATE UNIT.

Note

Specification of bombsight heavy oil (H oil) is VV-0-581. Specification for bombsight light oil (L oil) is Army Air Force Specification No. 3582-A.

(a) The servo unit requires very little oil. It

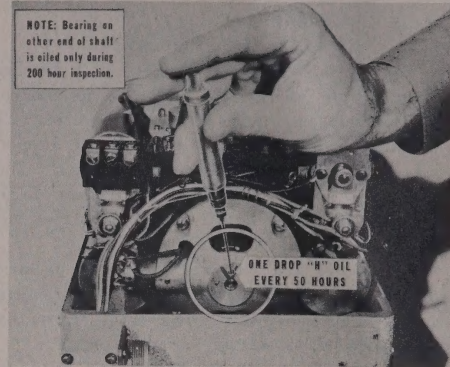


Figure 367 — Oiling Servo Motor Armature Bearing

is, therefore, suggested that either a hypodermic needle or a wire be used when introducing oil into an oil hole. When using the needle, force a single drop of oil to the point and then touch the drop to the part to be lubricated.

CAUTION

The servo unit can be damaged by over-oiling, and its performance impaired by using incorrect grades of oil. Be sure to use the exact amounts of oils specified. Use bombsight light oil ("L" oil), Army Air Force Specification No. 3582-A, or bombsight heavy oil ("H" oil), Specification No. VV-0-581.

(b) Place one drop of "H" oil on commutator end of armature bearing. (See figure 367.)

(c) Place one drop of "L" oil on bushings in large differential gears. (See figure 368, arrow No. 1.)

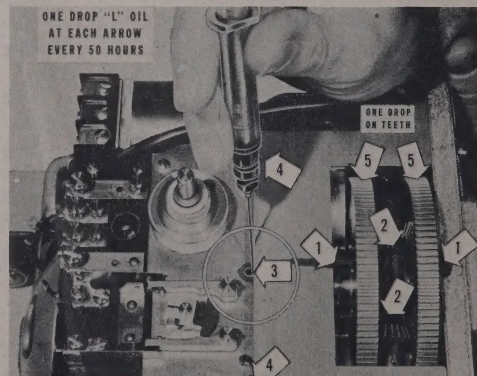


Figure 368 — Oiling Differential Assembly

(d) Deposit one drop of "L" oil on bearings of differential crosshead pinions. (See figure 368, arrows No. 2.)

(e) Place one drop of "L" oil on rear differential shaft bearing. (Arrow No. 3.)

(f) Deposit one drop of "L" oil on rear operating shaft bearings. (Arrows No. 4.)

(g) Place one drop of "L" oil on teeth of each differential gear. The oil will quickly work around the entire periphery of the gear, as soon as the motor is placed in operation. (Arrows No. 5.)

(h) Move circular cover aside and place one drop of "L" oil on front bearings of operating shafts. (See figure 369.)

(i) Oil clutch gear bearings by placing one drop of "L" oil in groove cut into operating clutch arm, as shown in figure 369. Also apply one drop of oil to the small hole in the brake arm. (See figure 370.)

(j) Lubricate cable drum bearing with five or six drops of "H" oil. Before this can be accomplished, it will be necessary to remove the Zerk grease fitting from the end of the cable drum shaft. If this grease fitting extends through the balance pot cover, it will also be necessary to remove the hex-head extension. With a small piece of clean cloth wrapped around a piece of stiff wire or a match stick, clean out the hole in the end of the cable drum shaft; then inject five or six drops of "H" oil. Catch any oil that runs out of the shaft with the cloth to prevent oil from getting on the balance pot. If the cable drum has been removed, apply a light film of oil to the outside of the shaft or to the inner surface of the bearing. Replace the shaft extension and the grease fitting

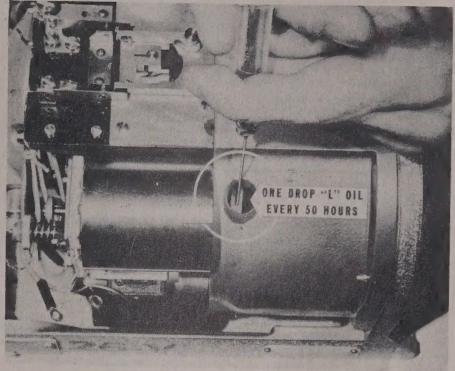


Figure 370 — Oiling the Clutch Gear Bearing

which serves as a plug to hold the oil in and to keep dirt out.

Note

Early Norden servo units were built with a plain bronze bearing in the cable drum. These bearings were lubricated with grease through the fitting in the end of the shaft. In later models the bronze bearings were replaced by Oilite bearings on which grease should not be used. The grease fitting, however, was not changed, and it is therefore difficult to determine which type of bearing is employed in a particular unit. In view of all this, it is recommended that all grease be cleaned out of the cable drum shafts and bearings. When applied every 50 hours as directed, "H" oil will provide excellent lubrication for both types of bearings, provided all old grease has been removed from the inside of the cable drum shaft, particularly from the small oil passage hole which leads from the center of the shaft down to the lower bearing surface. Compressed air may be applied to the lower end of this hole to blow any grease or dirt out through the hollow shaft.

(21) INSTALL COVER ASSEMBLY AND PRESSURE GREASE FITTING.

(a) Screw the grease fitting extension into the end of the cable drum shaft. Screw the pressure grease fitting into the end of the extension, making sure that the grease fitting outlet points upward.

(b) Install the limit cam assembly; clamp it tightly on the shaft.

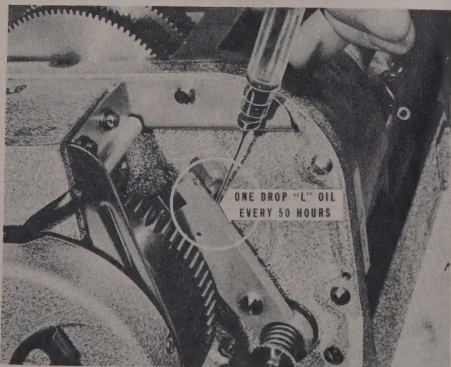


Figure 369 — Oiling the Operating Shaft Bearing

(c) Place the exterior cover assembly over the unit. Secure it in place, using the thin hex nut and the large internal tooth lock washer.

(d) Slip the balance potentiometer cover assembly over the potentiometer. Secure it in place with the cover latch.

f. SERVICE TROUBLES AND REMEDIES.

<i>Trouble</i>	<i>Probable Cause</i>	<i>Remedy</i>
BRAKES FAIL TO OPERATE.	Open solenoid winding.	Replace winding.
	Dirt in plunger guide sleeve or on plunger.	Clean sleeve and plunger.
	Broken leadwire.	Replace leadwire.
	Poor terminal connection.	Tighten terminal screws.
	Bent pull rod.	Straighten rod.
	Sticky or locked brake arm.	Clean or replace brake arm.
	Cover of brake solenoid housing loose.	Tighten cover.
	Thrust bearing missing.	Insert bearing of proper thickness.
D-C MOTOR DOES NOT OPERATE.	Sticky brushes.	Clean brushes. (See this section, paragraph 6, d, (10).)
	Broken leadwires.	Replace leadwire.
	Loose terminal connection.	Tighten terminal screws.
	Bearings frozen.	Replace bearings.
	Rust or foreign material on armature or pole pieces.	Clean. (See this section, paragraph 6, d, (10).)
	Clutch gears frozen.	Replace gears.
	Oil or grease on commutator.	Clean commutator. (See this section, paragraph 6, d, (10).)
	Open field coil.	Replace coil.
NO PECKING ACTION.	Push rod too short.	Replace rod. (See this section, paragraph 6, e, (9).)
	Bent push-rod	Straighten or replace rod.
	Dirt in operating solenoid bushing.	Clean bushing.
	Tension of trimmer spring too high.	Loosen or replace spring.

REVISION

DATED 30 August 1945

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of** AN 11-60AA-2

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current in the plate circuit by regulating the voltage applied to the grid.

Fig. 401 is a characteristic curve showing the relationship between grid voltage and plate current for a typical triode. From this graph, it can be seen

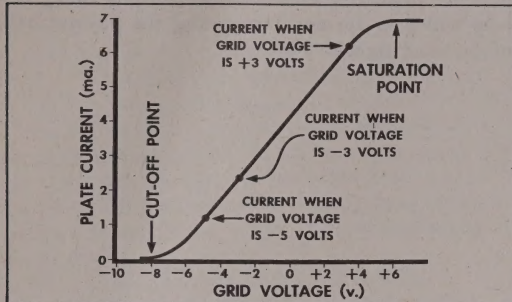


Fig. 401—Relationship Between Grid Voltage and Plate Current

that a grid voltage of -8 volts (cut-off point) will block all current flow in the plate circuit, and that a grid voltage of 16 volts (saturation point) will produce maximum plate current. At that point, all electrons emitted by the cathode are being attracted to the plate, and higher grid voltages can have no effect.

It is well to remember that vacuum tubes respond almost instantaneously. For example, the grid potential may fluctuate a million times a second, and the plate current will reflect these fluctuations faithfully with no appreciable time lag.

(2) AMPLIFICATION—Fig. 402 shows a triode with its grid charged by alternating current from a transformer. Assuming the voltage applied to the grid by the transformer fluctuates from -3 volts to +3 volts, the resulting pulsating plate current (as indicated by the graph in Fig. 401) will fluctuate between 2.3 and 6.1 milliamperes.

In Fig. 402, there is shown a resistor of 30,000 ohms in series with the tube in the plate circuit. The voltage across this resistor equals the resistance times

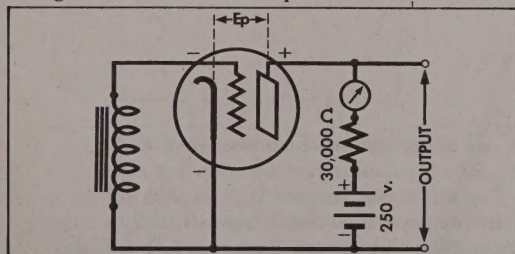


Fig. 402—Triode with Grid Charged by Alternating Current

the current flowing through it ($E=IR$). Therefore, as the current varies from 2.3 to 6.1 milliamperes, the voltage drop across the resistor varies from 63 volts ($.0023 \times 30,000$) to 183 volts ($.0061 \times 30,000$).

The total voltage applied to the plate circuit is 250 volts, but since this is a series circuit, the voltage across the tube itself (plate to cathode) is equal to the applied voltage minus the voltage across the external resistance. Thus, as the plate current varies from 2.3 to 6.1 milliamperes, the plate voltage varies from 187 volts ($250 - 63$) to 67 volts ($250 - 183$), or through a range of 120 volts. A fluctuation of only 6 volts on the grid has been amplified to a fluctuation of 120 volts at the plate!

The amplification factor (μ or $M\mu$) of the tube in this circuit is the plate voltage variation divided by the grid voltage variation or, in this example, 120 divided by 6, or 20.

Notice that the plate voltage across the tube decreases when the grid voltage is increasing, and that it increases as the grid voltage drops. Thus the signal applied to the grid is reversed in phase by the tube.

(3) GRID BIAS—In the preceding example, the voltage applied to the grid fluctuated between -3 volts and +3 volts and never reached the cut-off point or

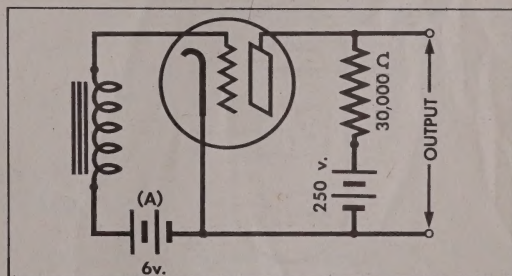


Fig. 403—Battery (A) Maintains Negative Bias on Grid

saturation point of the tube. For some control purposes, however, it is desirable to operate the tube in the vicinity of one of these critical points. This is accomplished by applying a steady D.C. voltage to the grid. Such a voltage is called the grid bias.

Suppose, for example, that a battery (A) is inserted between cathode and grid, as shown in Fig. 403. This will have the effect of applying a steady 6-volt positive potential to the grid with respect to the cathode when the transformer is not operating. As indicated by the graph in Fig. 401, the tube is now operating at the saturation point and current flow through the plate circuit is maximum.

Now, when the transformer applies its 3-volt alternating signal, it causes the voltage on the grid to fluctuate 3 volts each side of the bias or between +3 volts and +9 volts. During the negative half of the cycle or when the grid voltage is less than 6 volts, a corresponding drop in plate current will occur. But during the positive half of the cycle, when the grid

voltage is greater than 6 volts, no change in plate current will result as the plate current is already maximum.

Thus, the tube is responsive only to the negative half of the input signal. On the other hand, if the grid is biased negatively to the cut-off point (-8 volts), the tube will pass current only during the positive half of the input signal.

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8. INSTALL COMMUTATOR-END PLATE. (See figure 416.)—Install the commutator-end plate (15) on the bracket assembly (9) with the two 6-32 x 1/4-inch flathead screws (16). Be careful to insert the gasket (14) under the plate and sufficient end play spacing washers (5) to provide a very slight amount of end play in the armature bearings.

9. INSTALL END COVER.—Install the cover (17) over the commutator-end bracket assembly (9), using two 6-32 x 3/8-inch drilled fillister-head screws (18) and safety wire the two screws in place with a safety wire through the two screw heads. Secure the mounting base to the field assembly using two 10-24 x 3/8-inch round-head screws and medium spring lock washers.

(b) ATTACH INVERTER ASSEMBLY TO BASE ASSEMBLY.

1. Insert the four lead wires from the inverter into the base assembly and insert rubber mounting grommets if they were removed.

2. (See figure 415.)—Place a top mounting washer (8) over each of the four special mounting screws (9). These are the washers with the large diameter hole. Insert the screws (9) through the rubber mounting grommets and place a lower mounting washer (6) over each screw. These are the washers with the small diameter hole. Insert screws through the holes in the base assembly (3) and secure in place with four elastic stop nuts (12).

3. (See figure 413.)—Be sure that each lead

wire from the inverter is properly covered by insulating tubing. Connect the lug on the short black lead wire together with the terminal lug from prong A of the AN receptacle to ground. Use a 4-40 x 1/2-inch round-head screw inserted through the ground cable and the lower left-hand hole of the AN receptacle and secure these leads in place with an elastic stop nut on this screw. Solder the remaining two black leads, having the brown tracer, and which connects to the two slip ring brushes, to the two terminal lugs on the terminal block marked AC. Solder the white lead which connects to one of the commutator brush holders to the remaining lug on the terminal block which is marked DC. If the first type base assembly is used (see figure 412), the two a-c leads from the slip rings connect to terminals No. 1 and 2 and the white "DC" leads to terminal No. 3.

(c) INSTALL BASE PLATE. (See figure 415.)—Place insulating strip (2) over underside of base and install base plate with five 10-24 x 3/16-inch round-head screws and internal tooth lock washers.

(4) TESTS.—Test rotary converters running for ten minutes with a 7 1/2-ohm, 100-watt resistor across the output and with an applied voltage of 28 v, dc.

(a) Check input current rating. This should be three amperes, plus or minus five percent.

(b) Check output rating. This should be 2.7 amperes at 19 v, ac, plus or minus five percent.

(c) Check for dielectric strength to ground, using a high a-c voltage.

SECTION V TEST PROCEDURE

1. GENERAL

a. TESTS OF INDIVIDUAL COMPONENTS.—All necessary adjustments, and the tests to see that these adjustments are properly made, for each individual component of the C-1 autopilot system, have been included in the reassembly procedure outlined for each particular unit. These adjustments, and the test procedure necessary in making the adjustments, must be performed as the unit is being reassembled, and cannot be performed after reassembly because such adjustments usually must be made before assembly is completed.

b. MOCK-UP TABLE TEST.—The mock-up table test, outlined in the following paragraph, is, therefore, the test procedure for the entire autopilot system as a whole, and provides a check on not only the individual units, but also on their combined operation. The procedure outlined tells what should happen as

each of the test operations is performed. If results obtained are not in accordance with the correct results as outlined below, refer to the paragraph in section IV covering the unit which is not functioning properly. The proper corrective measures will be found therein.

2. MOCK-UP TEST PROCEDURE

a. MOCK-UP TABLE.—Figure 420 shows the units of the autopilot system properly connected on a typical mock-up table, ready for the mock-up test. Figure 421 shows diagrammatically the way in which the mock-up table is wired to make the proper connections to the junction box mounted on the table. In figure 421, the prong letters or numbers of each AN receptacle on each unit are shown, together with the wire numbers in the connecting cable. The junction box terminals to which these numbered wires attach are indicated on the outside edges of the rectangle which represents the

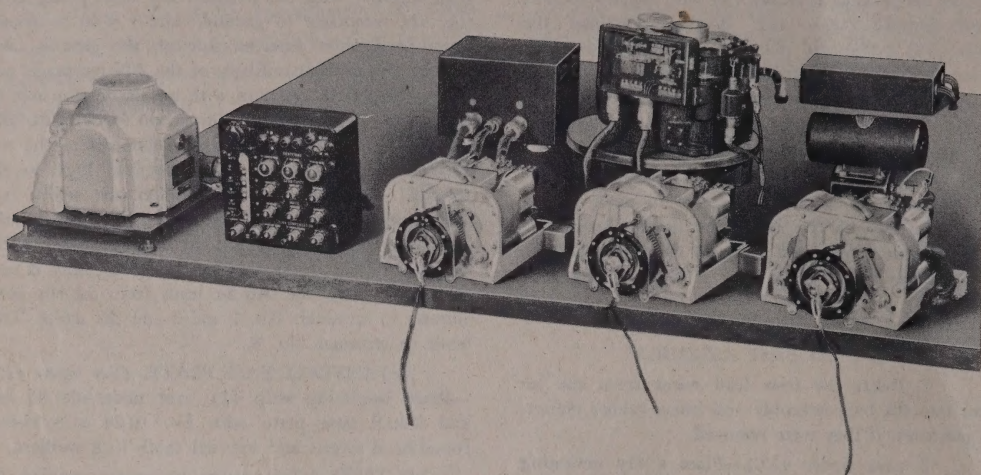


Figure 420 — C-1 Autopilot System on Mock-Up Table

junction box in the illustration. A 26-volt d-c power source must be provided, the positive terminal of which connects to terminal C-10 of the junction box, and the negative terminal to terminal D-10. A common ground lead is required, and all units of the system must be grounded to this ground lead. As shown in the diagram, junction box terminals D-8, 9, and 10 are also grounded to this lead.

b. **MOCK-UP TEST.**

(1) **MAKE CONNECTIONS.**—Connect all units to their proper AN plugs on the mock-up table. Connect ground wires to each of the servo units, the vertical flight gyro, the rotary inverter, the stabilizer, and the amplifier.

CAUTION

Be sure that the "Y" connector, marked with the yellow dot, is connected to the "Y" receptacle of the amplifier, also marked with a yellow dot. Be sure that the "Z" connector, marked with the green dot, is connected to the "Z" receptacle on the amplifier, also marked with a green dot. These connectors are identical; and, if connected to the wrong receptacle, the amplifier will be severely damaged.

(2) **WARM UP SYSTEM.**—Throw the master

switch bar on the autopilot control panel to "ON", and allow the system to warm up for from 10 to 15 minutes. This will start the flight gyro rotor, the rotary inverter, the servo unit motors, the stabilizer rotor, and the amplifier.

(3) **CUT IN CONTROLS.**—Place the aileron, rudder, and elevator switches on the autopilot control panel in the "ON" position. As each switch is turned on, the brake solenoids of the respective servo units should be energized.

(4) **CHECK OPERATION OF
FLIGHT GYRO ERECTING
CUT-OUT AND STABILIZER
DIRECTIONAL ARM LOCK.**

(a) Release the autopilot clutch on the stabilizer, and move the clutch so that the slide in the directional panel moves away from center. Do this in each direction and be sure that, as the erecting cut-out switch in the directional panel makes contact, the top roller in the vertical flight gyro stops rotating.

(b) Rotate the pilot's turn control knob on the autopilot control panel, to the left and to the right. As it is turned in each direction, the erecting cut-out in the vertical flight gyro should be energized, and the top erecting roller should stop rotating. The

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AN 11-60AA-2

OVERHAUL INSTRUCTIONS

FOR

AUTOMATIC PILOT

TYPE C-1

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